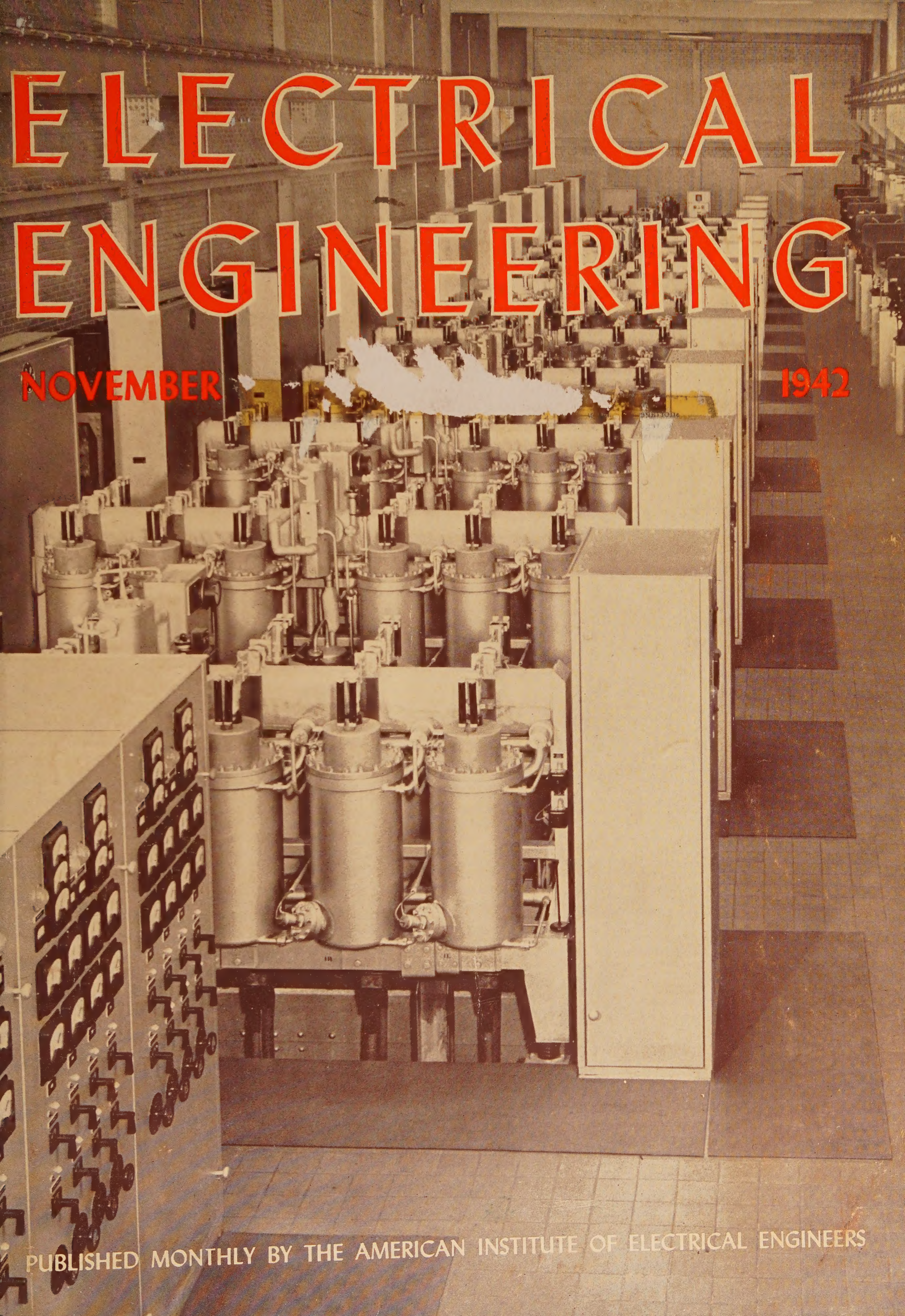
ELECTRICAL ENGINEERING

NOVEMBER 1942

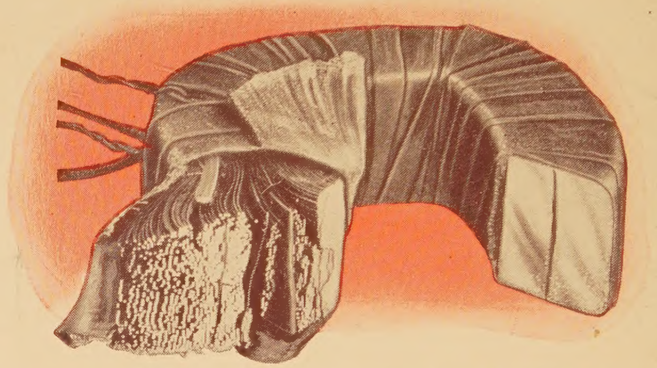


PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Cut baking time in half! WITH HARVEL 612-C VARNISH

Several coats of Harvel 612-C Varnish may be applied by merely allowing a one-hour bake between dips, and the completely treated winding can be baked in one operation.

These coils made by the Magnetic Windings Company are being lowered into the impregnating tank for Harvel treatment.



Coil consisting of 2500 turns of No. 24 enameled wire impregnated with Harvel 612-C and baked 8 hours showed perfect bonding and curing throughout.

When insulating coils and windings with varnish, why spend 48 hours in baking three coats of ordinary varnishes, when three coats of HARVEL 612-C Insulating Varnish can be baked and thoroughly set in 20 hours?

Not only does HARVEL 612-C cut baking time in half, but it insulates better because electrical windings are:

- **Dry Throughout**
- **Oil Proof**
- **Acid and Alkali Resistant**
- **Resists High Temperatures**

HARVEL 612-C INSULATING VARNISH is an internal drying type, which penetrates the innermost interstices of windings; sets an infusible state after baking; perfectly bonds even the smallest wires and keeps them in place. This varnish is comparable to phenol-aldehyde varnishes but there is this difference: the mildest solvents it is possible to use are included in 612-C. These solvents do not attack the enamel coating of magnet wires.

Because HARVEL 612-C solidifies throughout by heat-induced chemical polymerization and not by oxidation, there is no semi-liquid varnish that can run or ooze from coil interiors when they are heated or stressed in service.

This varnish will not soften or "throw out" on equipment operated at elevated temperatures nor on motors rotated at high peripheral speeds.

HARVEL 612-C INSULATING VARNISH can be applied on all classes of electrical windings, regardless of type, size and construction, either by vacuum and pressure impregnation or by dipping or brushing.

Write Dept. 36 for complete catalog of HARVEL and IRVINGTON VARNISHES.

STANDARD OF THE WORLD
IRVINGTON INSULATION

Send for complete Insulating Varnish Manual—contains 34 pages of pictures; charts; descriptions of 31 different insulating varnishes, paints and enamels; and application directions.

IRVINGTON
VARNISH & INSULATOR CO.

IRVINGTON NEW JERSEY, U. S. A.
Plants at IRVINGTON, N. J. and HAMILTON, ONT., CAN.
Representatives in 20 Principal Cities

ELECTRICAL ENGINEERING

Registered U. S. Patent Office

NOVEMBER

1942

The Cover: A rectifier substation in one of the plants built to supply the prodigious amounts of aluminum required for war. The units are of the ignitron type, arranged in groups of 12 to supply 5,000 cathode amperes.

Photo courtesy General Electric Company

TRANSACTIONS SECTION

(Follows EE page 588; a preprint of pages 771–834 of the 1942 volume)

VOLUME 61

NUMBER 11

Published Monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

Cut baking time in half! WITH HARVEL 612-C VARNISH

Several coats of Harvel 612-C Varnish may be applied by merely allowing a one-hour bake between dips, and the completely treated winding can be baked in one operation.

These coils made by the Magnetic Windings Company are being lowered into the impregnating tank for Harvel treatment.

Coil consisting of 2500 turns of No. 24 enameled wire impregnated with Harvel 612-C and baked 8 hours showed perfect bonding and curing throughout.

When insulating coils and windings with varnish, why spend 48 hours in baking three coats of ordinary varnishes, when three coats of HARVEL 612-C Insulating Varnish can be baked and thoroughly set in 20 hours?

Not only does HARVEL 612-C cut baking time in half, but it insulates better because electrical windings are:

- **Dry Throughout**
- **Oil Proof**
- **Acid and Alkali Resistant**
- **Resists High Temperatures**

HARVEL 612-C INSULATING VARNISH is an internal drying type, which penetrates the innermost interstices of windings; sets an infusible state after baking; perfectly bonds even the smallest wires and keeps them in place. This varnish is comparable to phenol-aldehyde varnishes but there is this difference: the mildest solvents it is possible to use are included in 612-C. These solvents do not attack the enamel coating of magnet wires.

Because HARVEL 612-C solidifies throughout by heat-induced chemical polymerization and not by oxidation, there is no semi-liquid varnish that can run or ooze from coil interiors when they are heated or stressed in service.

This varnish will not soften or "throw out" on equipment operated at elevated temperatures nor on motors rotated at high peripheral speeds.

HARVEL 612-C INSULATING VARNISH can be applied on all classes of electrical windings, regardless of type, size and construction, either by vacuum and pressure impregnation or by dipping or brushing.

Write Dept. 36 for complete catalog of HARVEL and IRVINGTON VARNISHES.

STANDARD OF THE WORLD
IRVINGTON INSULATION

Send for complete Insulating Varnish Manual—contains 34 pages of pictures; charts; descriptions of 31 different insulating varnishes, paints and enamels; and application directions.

IRVINGTON
VARNISH & INSULATOR CO.

IRVINGTON NEW JERSEY, U. S. A.
Plants at IRVINGTON, N. J. and HAMILTON, ONT., CAN.
Representatives in 20 Principal Cities

ELECTRICAL ENGINEERING

Registered U. S. Patent Office

NOVEMBER
1942

The Cover: A rectifier substation in one of the plants built to supply the prodigious amounts of aluminum required for war. The units are of the ignitron type, arranged in groups of 12 to supply 5,000 cathode amperes.

Photo courtesy General Electric Company

TRANSACTIONS SECTION

(Follows EE page 588; a preprint of pages 771–834 of the 1942 volume)

VOLUME 61

NUMBER 11

Published Monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

HIGH LIGHTS • •

Circuit-Breaker Performance. Recent tests on the response of high-voltage circuit breakers to both single- and double-frequency transient recovery voltages having natural frequencies up to 200,000 cycles per second showed that there were similarities in the performances of different types of breakers, that the difficulty of interruption did not increase indefinitely with increasing natural frequency, and that the maximum arcing time at a given voltage and current was obtainable in a high-power circuit-breaker testing laboratory (*Transactions pages 804–13*). In view of the present increase in the use of capacitors in banks up to 10,000 kva and the necessity of applying adequate power circuit breakers to the task of switching these large banks, an analysis of the duty on the circuit breaker and its effect on the system during switching is presented, along with test results on full-scale and miniature capacitor bank (*Transactions pages 821–31*).

Chicago Subway. First unit of the $64,000,000 Chicago subway now being completed, the five-mile State Street subway route, is expected to be in operation early in 1943. Centralized supervisory control of the all-relay type includes most modern accessories, such as an illuminated diagram board and remote-control dispatching equipment. Train movements will be controlled throughout by a modern signal and electropneumatic interlocking system with automatic stops (*Transactions pages 780–7*).

Reversed-Refrigeration Heating. Two plants now operating successfully indicate that it is possible and practical in some locations to obtain heat by a process of reversed refrigeration in which the hot condenser-cooling water of the refrigeration plant, usually discarded, is employed. The reversed-refrigeration method is described in this issue and operation data on two large installations presented (*pages 556–60*).

Carrier on the TVA System. Carrier-pilot relaying and carrier-telephone communication have been installed to meet the difficult requirements of relaying and intra-system communication on the extensive Tennessee Valley Authority system. Reasons for the selection of these methods and analysis of their application, the difficulties encountered, and their over-all performance are presented (*pages 561–72*).

Transient Recovery Voltages. Transient recovery-voltage characteristics are assuming a more important place in the design and operation of circuit breakers with the growth and increasing capacity of power systems. A method for determining these characteristics is presented in a paper in this issue, which also includes capacitance data for the more important circuit elements (*Transactions pages 771–9*).

Rectifiers. Mercury-arc rectifiers are being used increasingly to supply power to d-c utilization systems in the United States. High-speed anode switching appears to be the most satisfactory type of arc-back protection in the application of these units. Test data are presented on the performance of a multiple high-speed air circuit breaker for this use (*Transactions pages 788–96*).

Young Engineers and the War. An engineer in a letter to the editor clears up some uncertainties regarding the allocation of young engineers in industry, in the Army, and the Navy stating that highly skilled and trained men should not be inducted indiscriminately into the armed forces when it appears that they are more valuable to the war effort as members of the industrial army (*pages 585–6*).

Nomination of National Officers. Nomination of AIEE national officers to be elected in 1943 will be made at the national technical meeting, New York, N. Y., January 25–29, 1943, by the national nominating committee. Institute members are invited by the committee to contribute suggestions for nominees. Independent nominations also may be made (*page 573*).

Expense for Service Restoration. An analysis is presented of the effect of different types of overcurrent protective equipment and combinations thereof, on the man-hours and the automotive miles required to locate faults, to make necessary repairs, and to restore service (*Transactions pages 813–21*).

Motor Noise. Stator and rotor harmonics are primarily responsible for noise in induction motors. A paper in this issue discusses the resistance and reactance of the rotor with regard to the different harmonics, and presents methods of determining the magnitude of the forces that produce the noise (*Transactions pages 797–803*).

Committee Chairmen. Recently appointed chairmen of AIEE general and technical committees, some of whom already have been introduced (*Oct. EE. '42, pp. 528–30*), are presented to the membership through biographical sketches appearing in the "Personal" section (*pages 574–8*).

Vacuum-Tube Oscillators. Vacuum-tube oscillators have made possible many new applications in the fields of surface hardening, brazing, and soldering. Their advantages are extreme localization of the heat, speed, cleanliness, and uniformity of results (*Transactions pages 831–4*).

Joseph Henry—Pioneer. Henry's little-known experiments on "induction at a distance" were really the forerunner of radio, the AIEE president pointed out at a recent celebration in Philadelphia, Pa., of the 100th anniversary of Henry's experiments (*pages 550–3*).

AIEE Members Honored. The John Fritz Medal and the Hoover Medal were awarded recently to two members of the Institute, the former to Willis R. Whitney (A '01) and the latter to Gerard Swope (F '22) (*page 582*).

Impregnated-Paper Insulation. A report on the AIEE–Engineering Foundation research project on the stability of impregnated-paper insulation briefly reviews the results obtained since the inception of the project in 1936 (*pages 554–5*).

Wartime Efficiency. A Canadian engineer surveys Canada's progress in the prosecution of the war and prescribes a nationwide efficiency program to accelerate it (*pages 547–50*).

Engineering Man Power. The Engineers' Council for Professional Development recently adopted a resolution regarding the distribution of engineering man power for war (*pages 583–4*).

Coming Soon. Among the special articles and technical papers now in preparation for early publication in *Electrical Engineering* are: a review of American and European switchgear practice by J. B. MacNeill (M '36); a discussion of the use of organic plastics as electrical insulating materials by John Delmonte (A '36); an article on lightning protection of hazardous structures by G. D. McCann (A '38); a study of a-c wave form and wave-form standards by Frederick Bedell (F '26); an analysis of characteristics of the three-winding transformer ring-bus system by G. W. Bills (A '38) and C. A. MacArthur; a presentation of formulas for inverse functions of complex quantities by H. B. Dwight (F '26); a description of the use of a d-c board for a-c network analysis by W. E. Enns (A '37); a discussion of the design, manufacture, and installation of a 120-kv oil-filled cable system in Canada by D. M. Farnham (M '42) and O. W. Titus (M '36); a survey of air-blast circuit-breaker installations in Canada by H. W. Haberl (A '28) and R. A. Moore; a description of high-voltage air-blast circuit breakers by A. K. Leuthold (M '42); a discussion of current-transformer differential protection by P. W. Shill (M '42); and an analysis of a single-pole service-restoring device by E. E. Tugby (A '42).

Wartime National Efficiency

G. A. GAHERTY

Recognizing that war causes a dislocation in a nation's economy which in turn tends to lower its efficiency, a Canadian cites the necessity for expediting war production in Canada and suggests a national-efficiency program applicable to any nation at war. He declares that to achieve victory there must be a judicious allocation of men and materials for the maximum output of the implements of war and for the curtailed output of essential civilian goods; that there must be a rigorous practice of conservation on the part of individuals, business, and government; and that there must be a forfeiture of personal convenience where the national welfare is concerned.

CANADA now has been at war for three years and in that time has advanced far along the road to total war. It is timely to consider the war experiences of Canada, and the conclusions that can be drawn from them, since the war program of the United States, as it unfolds, is likely to follow much the same pattern.

At the very outset Canada became a major and rapidly increasing source of supply for Britain of aluminum, copper, zinc, foodstuffs, and automotive equipment. The financing of these purchases, a billion dollars of which were assumed by the Canadian Government, was a heavy strain on Canadian economy, but thanks to the foresight of the Canadian Department of Finance, stringent control of foreign exchange was imposed and enforced from the outbreak of war. While this brought the war home to Canadians who wanted American funds, it enabled Canada to finance the British requirements and also to meet her own financial obligations to the United States.

With the co-operation of industry, prices on war goods in Canada were for a time held down to prewar levels, but the industrial activity resulted in so much more money in the hands of wage earners that prices soon began to rise at an alarming rate. Sensing the danger, the Canadian Government with commendable promptness stabilized wages more than a year ago on a cost-of-living basis and established maximum prices for goods and services. These "ceilings" have since been maintained with considerable success, notwithstanding the efforts of certain labor and agricultural pressure groups.

ALLOCATE MEN AS WELL AS MATERIALS

Income and other taxes have been raised until those whose income is dependent upon the profits of corporations are taxed even more heavily than in Britain. The excess profits tax has been increased to 100 per cent, of which 20 per cent represents compulsory savings refundable after the war. Compulsory saving has been instituted for those on salaries and wages, and installment buying has been curbed. Gasoline, sugar, coffee, and tea have been rationed throughout Canada. The civilian use of rubber, copper, aluminum, and steel has been cut almost to nothing and even their military use is drastically restricted. The manufacture of many articles has been prohibited. Notwithstanding these measures, the shortage of labor has become so acute that vital war industries such as shipbuilding are now working at reduced capacity because of inability to get men. Selective service, which the Government has just introduced, is designed to make more men available for war work, but there is a definite limit to the Canadian man-power supply and the war effort can be further stepped up only through the more effective utilization of resources in man power and materials, in other words, by wartime national efficiency.

With all due respect for the splendid progress to date, this is no time for complacency. We are facing a crafty and unscrupulous enemy. He has cut us off from our main sources of three vital war materials: tin, tungsten, and rubber. He is taking a heavy toll of shipping and has played havoc with lines of communication, notably his severing of the Mediterranean route to Suez. Resources are being dissipated by the resulting necessity for convoying, for shipping via roundabout routes, for building ships to replace those he is sinking, and for constructing synthetic-rubber plants. His resources, at the same time, are increasing as he puts to work the enslaved peoples of Europe.

Make no mistake of it, victory can be achieved only by the complete mobilization of *all* our resources and their skillful employment in offensive operations; in other words, total war. *We must seek out and destroy the enemy.* It is not the total number of men in the army that counts, but the fire power and the mobility of the armed force with which to strike across the English Channel and in the China Sea. The Navy, Army, Air

Essential substance of an address given September 9, 1942, at a dinner meeting of the AIEE Pacific Coast convention, Vancouver, B. C., Canada.

G. A. Gaherty is president of the Montreal Engineering Company, Ltd., and a member of the Engineering Institute of Canada.

Force, and munitions industry must all be developed in proper balance so that an attack can be made with maximum effect.

MILITARY VERSUS POLITICAL STRATEGY

The great weakness of democracies is that their resources too often are frittered away through the deciding of war policies on grounds of political expediency rather than of military strategy. In Canada, for example, in calling up men for military service, whether they are married or single is the criterion, and single men who are too old are taken in preference to married men better fitted for fighting. In matters of this kind motives of self-interest still dominate, unfortunately. Our problem is to better, by democratic means, what the National Socialists of Germany achieve by enslavement, espionage, and lying propaganda. The stepping-up of Canadian national efficiency for war involves not only the problem of allocating each individual to his proper sphere, but also the problem of recognizing and counteracting the various subversive forces and of building a morale conducive to the *maximum output per individual.*

A major war causes an upheaval in national economy that in itself tends to lower national efficiency. In peacetime we live largely by taking in each other's washing. We exchange goods and services, money serving as a convenient medium whereby transactions can be effected that are fundamentally barter. The real wages for our services are not the money we receive, but what that money will purchase in goods and services. Such goods and services can be made available in wartime only at the expense of war production, and herein lies the main difficulty of a wartime economy. For the *total war* in which we are involved, the very *minimum standard of living* for everyone is indispensable, as is also the *maximum war output per individual.* The problem is how to get everyone working to his utmost with the very minimum of immediate reward.

LIVING STANDARDS VERSUS WAR PRODUCTION

A major war produces a tremendous dislocation of income, and consequently of purchasing power. On the one hand, many businesses such as the automobile business become war casualties; salaried people must work longer hours but for an income that is much reduced by taxation; those who have invested their savings in common stocks, the very foundation of our industrial progress, have their income taxed first in the hands of the corporation, and then again when it reaches the individual. On the other hand, wage earners in most cases are much better off. They are fully employed and they work longer hours often at high overtime rates. Some of them, who ordinarily would be considered unemployable command good wages under the present acute labor shortage. It is not surprising to find them breaking out in a spending rash and buying those things which heretofore they have been unable to buy. Thus we find an increased demand for the very goods the production of which must be curtailed or cut off to wage a successful war. It is this increased demand with a diminished supply of such goods and services that starts the inflationary spiral.

How best to curb the purchasing power of the individual while the war lasts is the question facing us today. Taxation, rationing, and curtailment of production of nonessentials all have their place, but if carried too far promote discontent, and for maximum output it is indispensable that our workers be happy. We must do our utmost to induce the workers to postpone the enjoyment of the fruits of their labor until after the war; in other words, to save. It is of no great importance whether the savings are in war loans, or in bank deposits, or in paying off a mortgage, so long as the money is not spent on services or goods the production of which involves the use of man power or of critical materials. It should be recognized, however, that a modicum of nonessentials, and even of luxuries is indispensable if the worker is to be kept happy, and we should concentrate on those that involve the least use of man power and critical materials.

WHAT IS "ESSENTIAL"?

The individual view as to what is "essential" depends largely on "whose ox is gored." There is the example of a labor deputation, in a Canadian province that prides itself on its patriotism, arguing that a local newsprint mill should not be shut down but that instead "nonessential" industries should be discontinued. Needless to say, the deputation did not elaborate on what industries it considered "nonessential" and why. We in the light-and-power business, until recently at least, have considered electricity to be indispensable. True, it is essential for the mass production of munitions, but for the household it is only a convenience. Further, the use of electric power for the display advertising of goods, the sale of which should be restricted, is a positive detriment to the war effort.

Essentiality is also a question of degree. A 4-page newspaper might be deemed essential, but not so a 40-page one. Wheat and flour are just as essential for our war effort as shells, but we do not need all the 400,000,000 bushels that the Canadian prairie produces. When production facilities exceed essential needs, efficiency generally can be achieved best by maintaining capacity operation in enough plants to produce only the required amount of goods, allowing these plants an adequate supply of labor and materials, and by closing down plants which produce goods in excess of exact needs. This already has been done in several Canadian industries, such as sugar refining.

Essentiality is a word that cannot be qualified. Either a thing is essential or it is not; but one cannot say that one thing is more essential than another, that tanks are more essential than guns. Both are needed

in definite proportions, although one may be needed in advance of the other. Already the Englishman has been forced to recognize this principle and has done away with priorities almost entirely. To obtain the requisite materials, however, a "certificate of essentiality" is required, and by this means nonessentials are cut off and war work is limited to what existing facilities and resources can produce efficiently.

We must always remember that there is a definite limit to what we can produce, and if we attempt to push our production too far we end by actually producing less. The law of supply and demand works as far as labor is concerned, and if the demand exceeds the supply the loafer comes into his own and efficiency drops. It is therefore imperative that we cut our suit according to our cloth and concentrate our attention on the more effective use of our existing resources—men as well as materials.

The curbing of nonessential spending by companies and by governments insofar as it involves the use of man power and of critical materials is just as important as in the case of the individual. Expenditures for extensions and replacements should be avoided wherever possible, and old equipment made to last. Accounting, sales, and other departments should be streamlined to eliminate all unnecessary posts, current maintenance should be deferred to the very limit. For example, a Canadian power company is adopting a bimonthly accounting period. It should be recognized, however, that company policy regarding replacements and maintenance is something that from its very nature is beyond the control of the government and that to secure the full co-operation of the companies, it is indispensable that labor and materials for maintenance and replacements be made available as necessary on a high priority. Otherwise the far-sighted plant manager is likely to stock up with spare parts and keep his plant in a high state of repair for fear of getting caught with a prolonged shutdown because of material or labor shortage.

GOVERNMENTS CAN ECONOMIZE TOO

For years civil government has been absorbing a greater and greater proportion of workers, but we have now reached a point where we must revert to the simpler life of earlier days. Our various government agencies now provide innumerable services ostensibly for the benefit of the public that could be dispensed with until after the war. Every civil servant that can be diverted to war work is just so much clear gain even if his full former salary is continued. Public-utility commissioners judges, and so forth, have the experience needed to administer the various war controls, and already in Canada the services of such men are being used in war jobs.

Throughout the country the construction of public works such as roads is rapidly being tapered off and before long we expect to see it cease altogether, as more and more of our political leaders are realizing that such work is carried out only at the expense of our war effort. A much more difficult problem arises in connection with works having a wartime justification such as housing projects. Here it is a case of relative importance. We must always remember that every house we build is at the expense of our production of guns and tanks, and we must decide which we need more. Obviously it is better to be somewhat overcrowded than to have our country overrun by the enemy. Too much overcrowding however results in discontent among workmen and a lowering of the war output per man. The danger is that local pressure groups will force the building of housing projects, when in the national interest the man power and the materials are more urgently required for other purposes. Such pressure groups usually are led by well-meaning citizens who think they are doing a public service, but their activities should be recognized in their true light as one of the most effective forms of sabotage.

In such questions the short-term view must be taken. It is the current expenditure of material and man power that counts. Whether it be a naval barracks, a munitions factory, or a housing project, the use of temporary instead of permanent construction is fully justified wherever any saving can be made in man power or critical materials, as this will mean that many more ships and guns can be turned out currently, and they are needed *now*.

Our armed forces constitute the chief drain on our total man power and therefore it is the efficiency with which they are employed that is the main factor in our war effort. The total *number* of men in the army means nothing. It is the number that can *strike* in a theater of war and their fire-power that counts. It is not the number of tanks and airplanes, but their fighting qualities that count. Too often in democratic countries sectional pressure leads to forces being immobilized to guard against possible hit-and-run raids and other military diversions. Also, shore establishment in dockyards may be built up, although repair work might be done with less use of man power by shipbuilding contractors. More men may be used to guard munition plants than would be required to restore any damage likely to arise from sabotage if the plants were left unprotected. These are questions that should be dealt with by the General Staff, but it is the duty of every citizen to see that the General Staff in making these decisions is unhampered by the sinister activities of pressure groups.

IF WE ARE TO STOP LOSING THIS WAR—

If we are to stop losing the war, further industries and businesses will have to be shut down. In some instances these necessary changes involve disturbing implications. South Africa, for example, is almost entirely dependent upon the gold-mining industry, but that industry is not essential to the war effort of the United Nations. It is

only by the drastic curtailment of nonessential industries that sufficient labor can be made available to relieve the acute shortage in war industries. The 40-hour week and the various conditions of labor which require the employment of three men where two would do, jurisdictional limitations which prevent a man from handling more than one job—these, too, are contrary to the national interest in wartime when all must produce the utmost.

We in the power business have had to slip into reverse. It is no easy matter to overcome the training of years and start saving electricity so that it will be available in sufficient quantity for essential war industries. That is to say, we must forego sales that are our bread and butter to take on business that is financially unattractive. At least one power company in Canada is already replacing copper conductors with iron wire on lightly loaded primary circuits so as to make more of this scarce metal available for war purposes.

Beware of the individual who looks upon the war as a golden opportunity to introduce his pet social theory, such as prohibition which was foisted on the country in the last war. Thumbs down on those who, by spreading racial, sectional, religious, or class prejudice, would divide and rule.

Promote, particularly among those in the lower income brackets, a better understanding of the reasons for war hardships. Provide the necessary incentive so all will work to the utmost. Save both as individuals and in one's official capacity so that man power and material can be conserved for war work. This is the way to step up our wartime national efficiency.

Joseph Henry—*Pioneer in Electrical Science*

H. S. OSBORNE
PRESIDENT AIEE

Henry's little-known experiments on what he called "induction at a distance," conducted 100 years ago, were really the forerunner of radio. Since this present war has been labeled a "radio war" because of the great importance in military and naval activities of the transmission of electromagnetic waves, it is particularly appropriate to take this radio anniversary as the occasion for honoring this great pioneer in electrical science.

ON October 21, 1842 in the hall of the American Philosophical Society, which is still standing on South 5th Street here in Philadelphia, Joseph Henry "communicated orally," (and I quote from the records of the American Philosophical Society) "an extension of the experiments, which he had previously brought before the Society, on electrodynamic induction. He had succeeded in magnetizing needles by the secondary current in a wire more than 220 feet distant from the wire through which the primary current was passing, excited by a single spark from an electrical machine."

The earlier experiments reported in June of the same year were recorded as follows in the minutes of the American Philosophical Society:

". . . a single spark . . . thrown on the end of a circuit of wire in an upper room, produced an induction sufficiently powerful to magnetize needles in a parallel circuit of wire placed in the cellar beneath, at a perpendicular distance of 30 feet with two floors and ceilings . . . intervening."

In the later experiments reported in October, a wire for transmitting had been stretched across the campus of Princeton University in front of Nassau Hall, grounded at one end by a plate buried in the ground. A second wire for receiving was erected in the back campus. A high-frequency oscillatory current was produced in the transmitting wire by discharging into it a battery of Leyden jars. A small steel needle was placed in the center of a spiral of wire, which formed a part of the receiving circuit. This needle was magnetized when the discharge took place in the transmitting circuit.

These little-known pioneer experiments are believed to be the first recorded experiments on radio transmission. They were carried out 45 years before the experiments of Hertz which established the existence of electrical radiation and determined many of its electrical properties. They were more than 50 years earlier than the pioneer work of Marconi in which this phenomenon was put to practical application—the first radio telegraph system.

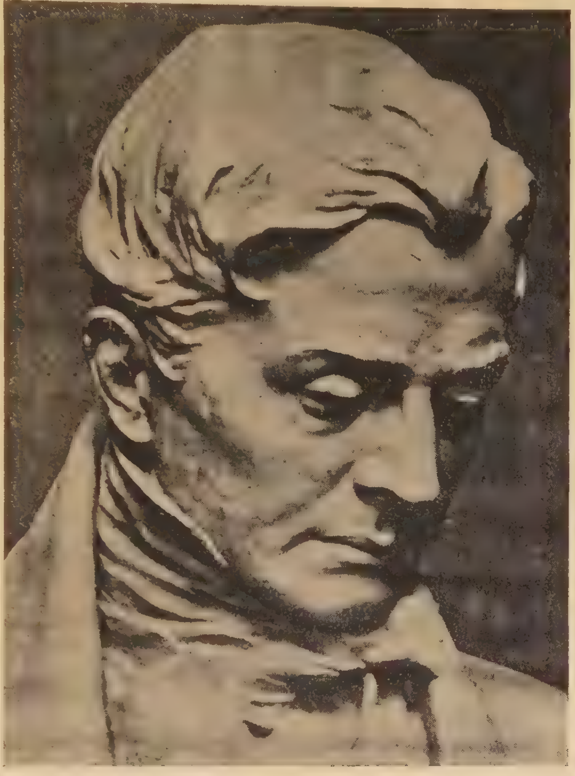
This centennial anniversary of these astonishing early experiments may be called a radio anniversary. While Henry's contributions to the development of science and of its application cover a wide range, it seems particu-

Essential substance of an address presented at a meeting of the AIEE Philadelphia Section, Philadelphia, Pa., October 12, 1942.

H. S. Osborne is plant engineer, operations and engineering department, American Telephone and Telegraph Company, New York, N. Y.

larly appropriate to take this radio anniversary as the occasion for pausing in the hurly-burly of the day's preoccupations to do honor to this great pioneer in electrical science. The knowledge and the application of radio are now being pressed forward with feverish activity, probably more intensively than any other branch of electrical science and its applications. Someone has labeled the present war "a radio war" because of the great importance in military and naval activities of the transmission of electromagnetic waves, of which Henry's experiments, just 100 years ago, were the forerunner.

It seems improbable that these experiments of themselves are one of Henry's great contributions to radio. They represent a case of Henry being so far ahead of the procession that it is doubtful how much direct effect these experiments had on the subsequent development of the electrical arts. Henry himself might well have advanced them to the point where they would have resulted in direct effect on the electrical arts, had he not, shortly after these experiments were made, dropped his individual research in order to organize and direct the newly formed Smithsonian Institution. For in Henry's remarkable career during the previous 15 years he had shown not only a capacity for exact research but a knack for practical design. While he was not interested in the commercial application of his scientific discoveries, this bent for the practical made his discoveries peculiarly effective in the subsequent development of the electrical arts and sciences.



Joseph Henry, a pioneer in electricity; from a bust sculptured by John Flanagan

Let me outline briefly the discoveries and accomplishments of Henry in the field of electricity which appear to have most important application in the radio art of today. First, as a background for the consideration of Henry's discoveries, I should mention two important discoveries which had recently been made in Europe. In 1820, Oersted in Denmark, had discovered that an electric current exerts a force upon a magnetized needle. This remarkable discovery led Sturgeon in England, and others, to construct electromagnets consisting of a spiral of bare wire wound upon an insulated iron core.

In 1827, Ohm's famous law was published in full in Berlin. This law, however, was little known or accepted even in Europe for a decade, a fact which well illustrates the poor state of communications at that time.

In 1829 Henry devised great improvements in the construction of electromagnets which made them much more powerful tools for investigation. Instead of winding a single spiral of bare wire on an insulated magnetic core as heretofore, Henry conceived the idea of insulating the wire and winding many closely wound layers on the core. This, of course, greatly increased the power of the electromagnet and transformed it from a scientific toy into a practical device for investigation and for use.

This improvement also laid the basis for applying to electromagnets and to the circuits in which they were used certain fundamental principles of design. Experimenting with these new magnets in 1830, Henry determined experimentally the correct proportioning between the winding of the magnet and the connection of the battery for maximum magnetic effect, showing that the intensity (or high-impedance) magnet and battery were suitable for operating over line wires of considerable resistance, while the quantity (or low-impedance) magnet and battery were suitable for local circuits. This result, as you know, could be derived mathematically from Ohm's law and from the relation between ampere turns and magnetism of an electromagnet. However, Henry derived this relation experimentally before he had any knowledge of Ohm's law. It is the first recognition of the necessity for properly proportioning the impedance of different parts of an electric circuit, a general principle of design which is fundamental in the design of radio circuits and which has, of course, very wide application in other fields.

These advances led Henry to set up in 1831 the first telegraph circuit using an electromagnet as a receiving device. The line ran between his house and his laboratory, and it is said that his wife used it to call the deeply engrossed professor home to meals. He supplemented this in 1835 by the addition of the first electromagnetic relay by means of which the relatively weak current received over the line was used to control the flow of a larger current in a local circuit.

In 1831 and 1832, working independently, Faraday in England and Henry in this country both discovered mutual induction and self-induction. Based upon dates

of publication, the discovery of mutual induction is credited to Faraday and that of self-induction to Henry. Henry's discovery of self-induction is probably the most widely known of his accomplishments and has been immortalized by the adoption by the International Electrotechnical Commission of the term "henry" for the unit of inductance.

Henry's work on self-inductance led him in 1835 to devise noninductive windings designed to reduce to a minimum the effect of self-induction. These were built by doubling the wire in the middle and then coiling the doubled wire—a principle of design which survives to this day.

His work on mutual induction led Henry in 1838 to discover that, by the proper proportioning of a primary and a secondary coil the voltage could be stepped up or down. He thus established the fundamental basis for the development of transformers. He also showed the variation in the current induced in the secondary circuit as the separation between the primary and secondary coils is varied. This is the principle of the variometer widely used in radio.

In 1842 Henry made a contribution of great import by confirming the oscillatory nature of the discharge of the Leyden jar. In 1827 Felix Savary of France, investigating the magnetization of small steel needles by the discharge of a Leyden jar, found to his surprise that the polarity of the magnetized needle varied with its distance from the conductor carrying the discharge. Up to that time it had been assumed that such a discharge was continuous in one direction. Savary raised the question whether these anomalous results could not best be explained by assuming that the discharge was not simply a single flow in one direction but instead was a series of rapidly succeeding discharges in opposite directions. In 1842 Henry reported the results of experiments which confirmed Savary's hypothesis and made a clear and authoritative statement of the phenomenon as follows:

> "The discharge, whatever be its nature, is not correctly represented (employing for simplicity the theory of Franklin) by the single transfer of an imponderable fluid from one side of the jar to the other; the phenomena require us to admit the existence of a principal discharge in one direction, and then several reflex actions backward and forward, each more feeble than the preceding, until the equilibrium is obtained. All the facts are shown to be in accordance with this hypothesis, and a ready explanation is afforded by it of a number of phenomena which are to be found in the older works on electricity, but which have until this time remained unexplained."

The establishment in this way of the existence of high-frequency oscillations was, of course, a great step forward in the electrical arts. It was mathematically explained 13 years later by Lord Kelvin and was the basis of the work of Hertz on electrical radiation, 40 years later.

Henry's work on the oscillatory character of the discharge of the Leyden jar directly preceded his experiments on what he called "induction at a distance," which are the occasion of this radio centenary. In these experiments he used the discharge of the Leyden jar. The knowledge that the discharges were oscillatory led Henry to surmise that these electrical phenomena of induction at a distance were of the same nature as the transmission of light. This striking flash of genius seems to have been another case of Henry being way ahead of the procession and deserves our further consideration.

In 1842 the "elastic-solid" theory of light was well established, having triumphed over its rival, the corpuscular theory. In accordance with the elastic-solid theory, the transmission of light consisted of a vibration in an elastic solid of most remarkable properties. The theory became established as a result of the work of Fresnel about 25 years earlier and held sway for many years.

It is true that Faraday in order to visualize the mechanism of the electrical phenomena which he was observing, had conceived the idea of tubes of force representing electrical strains in a surrounding medium. However, this medium had no relation in the mind of scientists to the so-called luminiferous ether, the medium by which light was transmitted.

It was not until 1864 that Maxwell, developing his electromagnetic theory, showed that the propagation of light could be considered as an electromagnetic phenomenon. This was confirmed in 1887 by the brilliant experiments of Hertz which showed that light waves and waves generated electrically are of the same nature.

This background makes thoroughly astonishing the following remark of Henry in reporting his experiments 100 years ago:

> ". . . when it is considered that the magnetism of the needle is the result of the difference of two actions, it may be further inferred that the diffusion of motion in this case is almost comparable with that of a spark from a flint and steel in the case of light."

This view was even more clearly expressed to Henry's students at Princeton at the time, in his lectures on natural philosophy. Here is the way it is recorded in the contemporary notes of one of the students:

> "Hence the conclusion that every spark of electricity in motion exerts these inductive effects at distances indefinitely great (effects *apparent* at distances of half a mile and more); and another ground for the supposition that electricity pervades all space. Each spark sent from the Electrical machine in the College Hall sensibly affects the surrounding electricity through the whole village. A fact no more improbable than that light from a candle (probably merely another kind of wave vibration of the same medium) should produce a sensible effect on the eye at the same distance."

While Henry thus clearly expressed his opinion we would wrong him if we were to assume that this was his set conviction. He was too great a thinker to be dogmatic in such a matter without data to prove that his postulate was correct. He showed the greatness of his nature by being accurate in his description of observed fact but tentative rather than cocksure in his deductions. His views on this point are illustrated by the following comment which he wrote a few years later:

> "Man, with his finite faculties, cannot hope in this life to arrive at a knowledge of absolute truth; and were the true theory of the

universe, or in other words, the precise mode in which Divine Wisdom operates in producing the phenomena of the material world, revealed to him, his mind would be unfitted for its reception; it would be too simple in its expression and too general in its application, to be understood and applied by intellects like ours."

To my mind, pausing to honor this great man is not merely a graceful gesture toward the past but also has a real significance in connection with the problems of today. Joseph Henry's career is at any time an inspiration. Son of a day laborer, largely self-educated, he was located in a frontier country which was far from the main stream of scientific thought in Europe and with most inadequate means of communication. But, working incessantly and armed with plain heroic magnitude of mind, he became a great leader of science, not only of this country, but of the world.

He had to a high degree the qualities of a great pioneer of science—qualities necessary for progress at any time in the world's history—curiosity and industry which enabled him to discover new phenomena, accuracy in the observation and correlation of fact, the imagination to see the significance of new facts, even when that meant departing from established paths of thought, and the wisdom to be tentative in his general conclusions.

Perhaps such qualities were never more needed than today. Like Henry we are working in a time of rapid change, when there is great need for the pioneer spirit. Today the changes are perhaps more rapid and on a broader front than ever before. Today we are faced with rapid changes, not only in the field of physical sciences, but in that very broad and difficult field called the social sciences. And in saying this, I have in mind both the war, with its urgent problems, and the postwar period, which will bring new problems just as important and difficult.

I believe, as we measure our wisdom and our strength against the problems and events of these days, that we can be helped by the inspiration of Joseph Henry's life and accomplishments.

General Electric Company photo

Steel parts vital in the production of war goods are first heat-treated in the rotary-hearth electric furnace, the large cylinder in the background, then in the vertical cylindrical air-draw electric furnaces in the foreground

Stability of Impregnated-Paper Insulation

J. B. WHITEHEAD
FELLOW AIEE

Results obtained in the AIEE–Engineering Foundation research project on the stability of impregnated-paper insulation, since its inception in 1936, are reported briefly. Some unexpected properties of impregnated-paper insulation have been discovered and findings pertaining to paper density, high-stress internal ionization as the origin of failure, and impregnation temperature versus dielectric strength and life indicate that further research in these fields is desirable.

A SUMMARY of the principal problems studied in the AIEE–Engineering Foundation research project on the stability of impregnated-paper insulation and results of laboratory investigations are outlined in this report. More detailed accounts of specific phases of the work covered in this project already have been published in AIEE *Transactions*.[1–4]

PAPER DENSITY

Laboratory studies in accelerated life tests of the influence of the density of the paper on the breakdown strength of impregnated-paper insulation have been conducted. The studies were in two series, one using a heavier oil as employed in solid-type cables, and the other using a thin oil as employed in oil-filled cables. The same four grades of paper of different values of density were used in both series.

The results in both cases showed a marked decrease of dielectric strength with increasing paper density, the type of variation being much the same for each oil. However, dielectric strength and life for the series using the thin oil are substantially higher than for that using the heavier oil.

Raising the viscosity of the thin oil and lowering the viscosity of the heavier oil so that both have the same viscosity during impregnation have little effect on the breakdown strength at standard test temperature of 40 degrees centigrade. Specimens impregnated with the heavy oil show no change in behavior. Increasing the viscosity of the thin oil results in a slightly lower dielectric strength. This may be accounted for, however, by the low impregnating temperature, 40 degrees centigrade. When the two oils have the same viscosity at impregnation, the values of power factor and of oil content at 40 degrees are approximately the same.

The explanation of the decrease of dielectric strength and increasing paper density is to be found in the increased dielectric constant of a denser paper. This increase in dielectric constant throws a greater proportion of the total stress on the oil channels and their critical breakdown stress is reached at a lower over-all voltage.

At first, some engineers were loath to accept this evidence that the dielectric strength of impregnated paper decreases with increasing paper density. It is stated that in manufacture, cables containing high-density paper give a higher dielectric strength than those using paper of lower density. While there are comparatively few published data of the results observed on cable, it is clear that the relationship between paper density and dielectric strength found in this research differs radically from the relationship reported for finished cable. In the case of impulse test on cables, a different mechanism of failure may readily explain the difference.

In the case of solid-type cables on which tests of longer duration have been reported the values of *specific* dielectric strength for all types of paper are considerably lower than in this research; this well may suggest a different mechanism of failure even for tests of duration comparable to those in this research. Some things which have been suggested as possibly bearing on a difference in mechanism are: that cables are made with stranded conductors as compared with the smooth conductors in this research; that cables must be capable of withstanding bending, and are bent; and that solid-type cables cannot remain completely filled with oil due to expansion and contraction of the impregnant. However, until more complete information is available concerning the cable tests, it will be difficult to assign a definite cause for the apparent discrepancy. In view of the conflict described, it is obviously desirable that the influence of the density of the paper be studied further.

INFLUENCE OF PAPER THICKNESS

A pronounced decrease of dielectric strength with increasing paper thickness has been found and described in a published paper.[2] This result may be attributed to the well-known fact that the breakdown stress of thin oil films decreases with increasing thickness. Further discussion in the published paper analyzes the results and indicates that variations in the value of the critical stress in the oil channels are due to space-charge accumulations at the interfaces between paper tapes and oil channels.

The results of research on paper thickness confirm

Essential substance of a report prepared by Doctor Whitehead and endorsed by the advisory committee of the AIEE–Engineering Foundation research project on the stability of impregnated-paper insulation. This research has been supervised by the following subcommittee of the AIEE committee on research: H. H. Race, chairman, W. A. DelMar, H. Halperin, E. R. Thomas, R. W. Atkinson.

J. B. Whitehead is director of the school of engineering, Johns Hopkins University, Baltimore, Md.; he has conducted the work on the AIEE–Engineering Foundation insulation research project since its inception.

the general conclusions of all these studies that failure begins in an oil channel, and that space-charge accumulations in the oil channels have an influence on the critical or breakdown stress in the channels. The results here are very definite and no special need for further study is indicated.

INFLUENCE OF WIDTH OF OIL CHANNEL

The dielectric strength of impregnated-paper insulation assembled cable-fashion decreases with increasing oil-channel width between successive convolutions of tape, up to a channel width of one-eighth inch and is constant thereafter. Using the thin oil the decrease is about 9 per cent, using the heavier oil, about $6^1/_2$ per cent, as the channel width increases from zero to one-eighth inch.

The increase of dielectric strength with decreasing channel width is probably accounted for by the increasing limitation in the volume of space-charge accumulation. The results in this study again show the higher dielectric strength and longer life of specimens impregnated with the thin oil, confirming the results in the studies of the influence of the density of the paper. In view of the definite character of the results, there seems to be no special need for further studies of this question.

INTERNAL GASEOUS IONIZATION

The basis of the method for detecting the beginning of internal gaseous ionization has been described in a published paper.[3] The method, however, as adapted to the present work, has been modified substantially. It now consists of a rearrangement of the Schering bridge so that a balance is obtained for the principal range of frequencies found in a gaseous discharge in impregnated paper, and at the same time a filtering out of the 60-cycle component in the balance arm. Recent work has included the incorporation into the experimental setup of a continuous recording instrument, which indicates the beginning of internal ionization and measures the subsequent increase of volume or magnitude of ionization. This method has been applied to the study of the behavior of impregnated-paper specimens as used in this project and has already shown that it is possible to interrupt a test on a specimen when failure has begun, but has not advanced through the wall of the insulation more than two or three layers of paper. Not only is it possible thus to locate the initial failure, but also, in other specimens, the rapidity of its advance, and the point at which it swings over into an unstable thermal failure. The studies employing this method are still in the early stages and have given very great promise.

The partial failures in the use of this method and their subsequent dissection and study have confirmed other indications that failures in impregnated paper usually begin in the oil channels. They also have given evidence of causes of power-factor increase and the rate of increase of loss and approach to failure. This method has given greatest promise for further information as to failure in impregnated-paper insulation and is strongly recommended as a promising field for further study.

OPEN VERSUS CLOSED SPECIMENS

The studies on open versus closed specimens are short-time low-temperature studies and have never given any evidence of oxidation or other type of disturbing influence attributable to the open bath in which the specimens are tested.

Comparative tests on open and closed specimens (nine each) resulted in no appreciable differences in dielectric strength or life. The behavior of both closed and open specimens in regard to power factor was similar to data on closed specimens furnished by Doctor H. H. Race, although in the AIEE–Engineering Foundation research the power-factor values are substantially lower, probably because of the difference in temperature.

Power factor–voltage curves in these studies up to 400 volts per mil were almost invariably flat after tests up to and above 100 hours, and with stresses, up to 800 volts per mil. We also have found no power-factor changes in specimens which have remained in the open bath for periods of several weeks.

Tests reported in the paper, "The Life of Impregnated-Paper Insulation,"[5] show flat power factor–time curves for certain oils (Figures 3 and 4) up to 100 hours at 40 degrees, the stress increasing progressively up to and beyond 800 volts per mil.

In view of these and other allied results, it has been assumed that for the relatively low temperature and short time of these tests, the results are not influenced by the open character of the test bath, because the mechanism of failure is predominantly ionization and not chemical deterioration.

Recently, however, there has been some renewed discussion of possible limitations of accuracy of open versus closed test baths, if such tests are conducted at elevated temperature or for more than a few hours. It is certain that the limits of temperature and time in which open baths may be considered as reliable are not known. The relative simplicity of the open-bath method as compared with the closed-bath method undoubtedly gives it certain advantages. It would appear, therefore, that a comparative study of open and closed baths with special reference to the limitations of the former offers promise of useful results.

REFERENCES

1. The Dielectric Strength and Life of Impregnated-Paper Insulation—I, The Influence of the Density of the Paper, **J. B. Whitehead.** AIEE *Transactions*, volume 59, 1940, pages 715–20.

2. The Dielectric Strength and Life of Impregnated-Paper Insulation—II, the Influence of the Thickness of the Paper, **J. B. Whitehead.** AIEE *Transactions*, volume 59, 1940, December section, pages 660–2.

3. The Detection of Initial Failure in High-Voltage Insulation, **J. B. Whitehead, M. R. Shaw, Jr.** AIEE *Transactions*, volume 60, 1941, June section, pages 267–72.

4. The Dielectric Strength and Life of Impregnated-Paper Insulation—III, **J. B. Whitehead.** AIEE *Transactions*, volume 61, 1942, August section, pages 618–22.

5. The Life of Impregnated-Paper Insulation, **J. B. Whitehead.** AIEE *Transactions* volume 52, 1933, pages 1004–12.

Heating by Reversed Refrigeration

REGIS D. HEITCHUE

GIVEN a source of heat which results in a reasonable coefficient of performance, the practicability of a reversed-refrigeration plant will depend upon the cost of electricity relative to coal, gas, or oil, and the initial cost, which in turn will depend upon the ratio of heating to cooling loads. Obviously a detailed survey by a competent air-conditioning engineer would be required to determine whether or not a contemplated installation meets the technical requirements.

Because of the growing popularity of refrigeration equipment for both comfort and process cooling, it reasonably can be expected that the use of reversed refrigeration for heating will increase when it becomes possible to resume the manufacture of the required equipment. In industrial plants requiring refrigeration throughout the year, the relatively hot condenser-cooling water now being wasted might be used to good advantage.

The elements of reversed refrigeration, a method by which heating may be accomplished, are to be found in all refrigerating and air-conditioning systems. In reversed refrigeration the heat derived from the motor and the compressor and from the substance cooled—air or water—is utilized. The method is particularly applicable in industrial plants requiring refrigeration throughout the year, where the relatively hot condenser-cooling water now being wasted might be salvaged for heating purposes. Two industrial reversed-refrigeration plants now in successful operation are described here.

WHAT REVERSED REFRIGERATION IS

One need look no further than one's own kitchen to see the workings of reversed refrigeration. The electric refrigerator has all the elements of this fascinating heating scheme. Suppose the ice trays are filled with cold tap water. Soon this water becomes ice. In the process, the kitchen is heated by an amount equal to the electric energy used by the motor plus the amount of heat taken from the tap water in the trays.

Every refrigerator, air conditioner, or reversed-refrigeration heating system works exactly this same way; in fact the name reversed refrigeration is a misnomer. Heat is extracted from air or water, is combined with the heat developed by the motor and compressor, and added to other air or water. If the cooled air or water is sent to the living or working areas, the conventional air-conditioning system is the result. If, instead, the heated water or air is circulated, a reversed-cycle refrigeration plant is the result. The heat comes from two sources: the electric energy converted to heat by the motor and compressor, paid for as kilowatt-hours; and the substance cooled. It is because this second quantity of heat can be taken from the free air or from low-cost water that the system has the appearance of giving more than is paid for. Heat is simply extracted from an additional source, which, although of lower temperature than the room being heated, still contains a large quantity of heat that can be made available.

TECHNICAL REQUIREMENTS OF A REVERSED-REFRIGERATION PLANT

Source of Heat. Essential to the operation of a reversed-refrigeration heating plant is a suitable source of heat. Not only must the heat source be available in ample quantity, but it must also exceed certain minimum temperature limits, if the gain in heat is to be worth-while.

There are two natural sources of heat: outdoor air and water. In cool climates where freezing temperatures are often encountered, water is the only satisfactory source of heat. In the case of the household refrigerator, the tap water, plus the heat removed from the food is the source. In a large plant requiring considerable heat, the cost of using city water would probably be too great or there might be restrictions on its use for such purposes. Also, in the colder climates, the temperature of the city water, rivers, or lakes would, in all probability, for reasons to be pointed out later, be too low. The drilling of private wells, then, appears to be the only way of affording a source of heat in the colder climates. Where well water is not available or it is not feasible to drill wells, the use of the reversed-refrigeration heating plant is obviously not practical.

Where the outdoor temperature seldom falls to freezing, air may be employed as the source of heat. A disadvantage of air as a source of heat however, is that its temperature is lowest when the need for heat is greatest. Since the efficiency of a reversed-refrigeration plant is greatly affected by the temperature of the source, the use of air might necessitate a larger plant than would be required if water were used.

The quantity of heat to be removed from the source would obviously depend upon the size of the intended

Essential substance of a paper presented at a meeting of the AIEE Springfield (Mass.) Section, September 8, 1941; subsequently expanded to include operating-results data.

Regis D. Heitchue is an air-conditioning engineer in the merchandise engineering department of the Westinghouse Electric and Manufacturing Company, East Springfield, Mass.

installation. The temperature of the heat source, however, has fairly strict economic limits. In the household refrigerator, heat is removed from the water and given up to the room even during the freezing process. While it would be possible to utilize the heat thus liberated, it would not, in most cases, be economically practical. The minimum temperature limits are 45 degrees Fahrenheit for air and 40 degrees for water. Of course, these limits may be modified somewhat, but as will be shown later, the coefficient of performance or efficiency falls off appreciably with a decrease in the temperature of the heat source.

Coefficient of Performance. The efficiency of a refrigerating machine is defined as the coefficient of performance (*COP*), and is simply the ratio of output to input. In a reversed-refrigeration machine, the output is measured at the condenser, and, disregarding losses, is equal to the heat represented by the motor watts plus the heat removed from the source, or the refrigeration effect. The input is the heat equivalent of the motor watts. The expression then for the efficiency is:

$$COP = \frac{\text{heat from electricity} + \text{heat from source}}{\text{heat from electricity}}$$

It was said that the coefficient of performance is greatly affected by the temperature of the heat source. It is also true that the coefficient of performance is very much dependent upon the condensing temperature, which in turn is dependent upon the medium employed to transfer the heat from the refrigerating machine to the building. In the household refrigerator, the room air is circulated over the air-cooled condenser, absorbing heat directly from the refrigerant through the metal of the condenser. Although this method is practical for small installations, it is not for large ones. Instead, water-cooled condensers are employed. The heat from the refrigerant is first transferred to water and then by means of additional heating coils, the heat is transferred from the water to the room air. The lower the temperature of the water, the higher will be the coefficient of performance. Offsetting this advantage, however, is the disadvantage that as the temperature of the water is decreased, the size of the heating coils must be increased, requiring a greater investment in equipment. In practice, it would be necessary to strike a balance between operating cost as determined by the coefficient of performance and amortization and interest charges. The coefficient of performance for an actual machine, a 100-horsepower condensing unit operating at several evaporating and condensing temperatures is shown in Table I.

Table I. Effect of Evaporating and Condensing Temperatures on the Coefficient of Performance

100-Ton Condensing Unit

Evaporating Temperature Deg. F	Condensing Temperature Deg. F	Heat Absorbed at Evaporator (Cooling Effect) British Thermal Units	Motor Watt-Hours Input	Heat Equivalent of Motor Watts British Thermal Units (Column 4×3.415)	Heat Rejected at Condenser (Heating Effect) British Thermal Units (Column 3+Column 5)	COP (Column 6÷Column 5)
50	96	1,430,000	87,000	297,000	1,727,000	5.80
40	96	1,185,000	83,300	285,000	1,470,000	5.15
34	96	1,040,000	80,500	275,000	1,315,000	4.78
50	117	1,290,000	100,000	341,500	1,631,500	4.77
40	117	1,055,000	94,500	323,000	1,378,000	4.26
34	117	920,000	90,400	309,000	1,229,000	3.97

Operating Costs. The installation and operation of a reversed-cycle heating plant is economically practical only when the total cost of operation is equal to or less than the cost of heating by other methods—coal, gas, or oil. The operating cost is made up of the following:

1. Interest on the capital investment.
2. Amortization of capital investment.
3. Maintenance charges.
4. Electricity.

When the refrigeration and air-conditioning equipment is necessary during the summer months to provide cooling, and the heating load is not much greater than the cooling load, the capital investment and interest charges are not of major consideration. It can be argued justly that only the depreciation and maintenance expense should be charged against winter operation. In such cases, the cost of electricity would be the determining factor. If the cost is high compared with coal, gas, or oil, it might be cheaper to install a separate heating plant. On the other hand, if electricity is cheap, the installation of a separate heating plant might not be warranted. If there were a considerable disparity between the heating and cooling loads and if cooling were a summer-time requirement, then winter operation should be charged with only the additional equipment employed and, of course, depreciation charges on the whole plant. If the cost of operation thus computed were less than that of other methods in which interest and amortization charges were also included, the reversed-refrigeration plant would be economically justified.

PRACTICAL APPLICATIONS

The reversed-refrigeration plants chosen for discussion were selected because of their sizes, locations, sources of heat, and methods of changing from heating to cooling. The plant on which the operating data is presented is probably the largest reverse-refrigeration heating installation in existence.

Reversed-Refrigeration Plant in California. As might be supposed, air is the source of heat of the plant which serves the Westinghouse Electric and Manufacturing

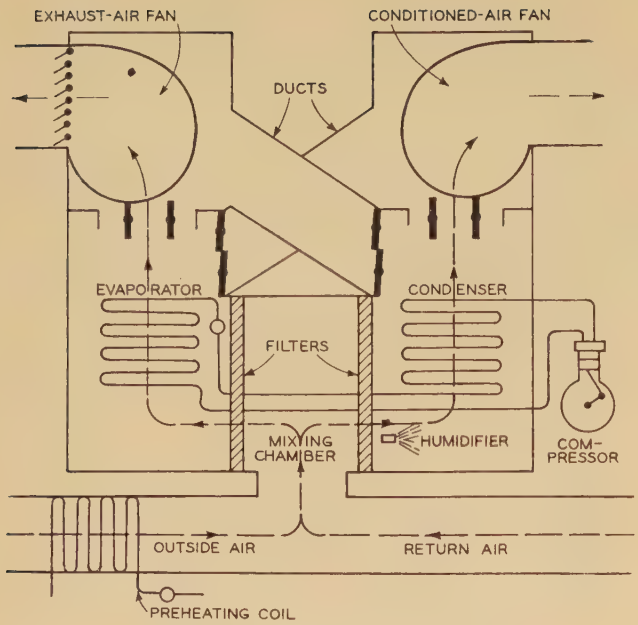


Figure 1. Heating cycle

Company district office building in Emreyville, Calif. The heating equipment consists of two $7^1/_2$-horsepower compressors, extended-surface evaporators of the type commonly used in air-conditioning work, and air-cooled, extended-surface condensers, a conditioned-air fan, and an exhaust-air fan (Figures 1 and 2).

Winter operation (Figure 1) is as follows. Air drawn in from outdoors and air returned from the air-conditioned space mix in the mixing chamber in about equal proportions and divide into two streams. One of these streams flows through a set of filters, then over the evaporator where the air gives up heat to the refrigerant in the evaporator. The air then passes through the open dampers into the exhaust-air fan which discharges the air to the outdoors. The other stream flows over the other set of filters, then over the condenser, which heats the air, after which it passes through the open dampers to the conditioned-air fan which delivers the air to the ducts leading to the air-conditioned space. When the outdoor temperature falls below 35 degrees Fahrenheit a thermostatically controlled valve admits city water to the preheating coil. The city water being at a temperature of around 60 degrees Fahrenheit adds sufficient heat to the incoming outdoor air to prevent the formation of frost at the evaporator. With an outdoor temperature of 35 degrees Fahrenheit, the air delivered to the air-conditioned space leaves the condenser at 90 degrees Fahrenheit, and the coefficient of performance is approximately 5.

There may be some doubt as to how it is possible to obtain such a high coefficient of performance in view of what was said previously concerning the outdoor temperature. The answer is the mixing chamber. The temperature of the air in this chamber is higher than that of the outdoor air and yet lower than that of the air returned from the air-conditioned space. The result is that the evaporating temperature is higher than would be the case if only outdoor air were circulated over it, and the condensing temperature is lower than it would be if only indoor air were circulated over it. By thus introducing and discarding the air needed for ventilation (It is made to pass first over the condenser and then, when it is discharged, over the evaporator.) most of the heat is regained at the evaporator that was given up to the ventilation air at the condenser.

When weather conditions are such as to require cooling, a thermostat located within the building changes the positions of the two sets of dampers, closing the one and opening the other. Figure 2 shows the dampers thus manipulated. In this cycle, the cooled air from the evaporators is delivered to the air-conditioned space by the conditioned-air fan, and the air from the condensers is discharged to the outdoors by the exhaust-air fan.

An effort was made to obtain operating data on this plant, but inasmuch as the equipment very often is called upon to furnish heat in the morning and cooling in the afternoon of the same day, the watt-hour meter readings do not reveal the energy consumed for heating alone. For the purpose of determining costs, it might prove worth while to install two watt-hour meters, one for the heating cycle, and the other for the cooling. Switching from one meter to the other could be accomplished by a suitable device attached to the damper-operating motor.

Reversed-Refrigeration Plant in Connecticut. Anyone having only a meager knowledge of reversed refrigeration would readily agree that the last place he would look for a reversed-refrigeration plant would be in New England. Yet, what is probably the largest such heating plant in the world is installed in the new administration building of the United Illuminating Company, New

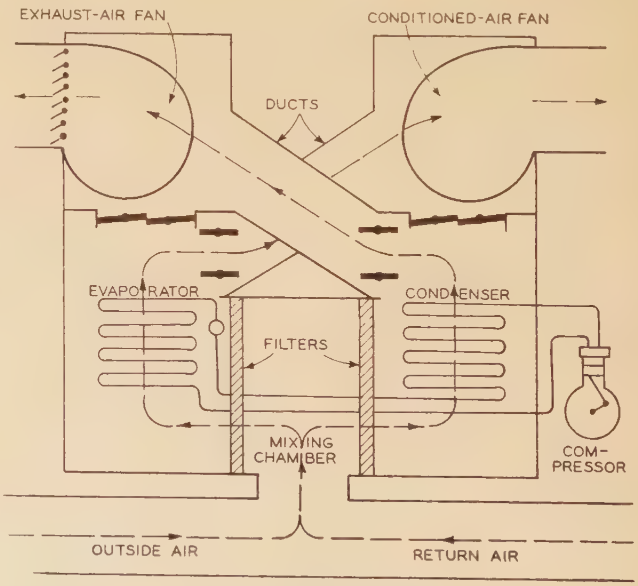


Figure 2. Cooling cycle

Haven, Conn. This is made possible because of a large underground body of fresh water, having a temperature which deviates very little from 58 degrees Fahrenheit throughout the year. Figure 3 shows the refrigeration equipment of this plant.

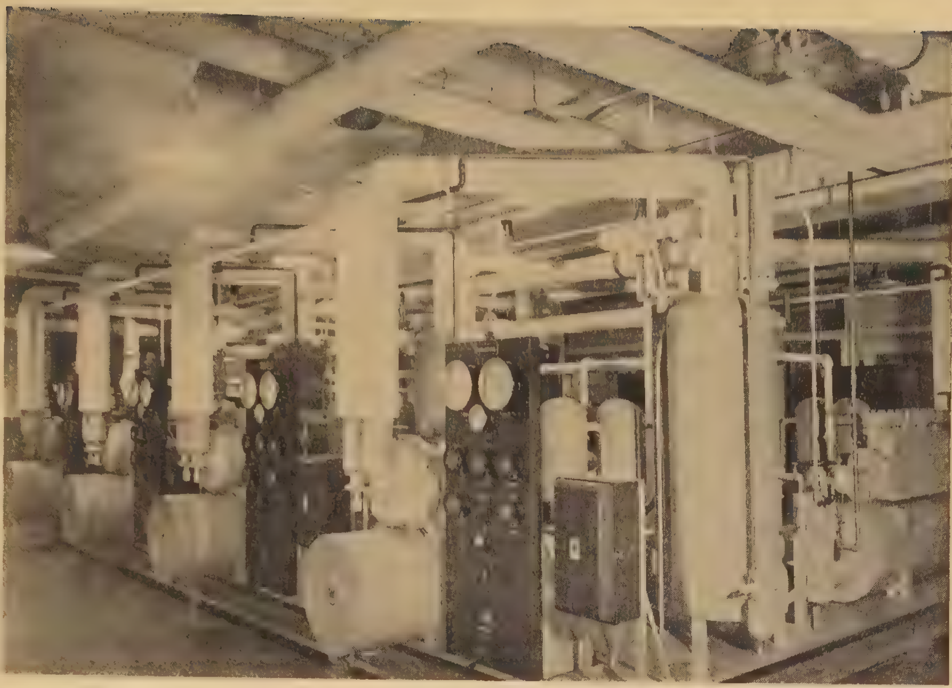


Figure 3. Refrigeration equipment in the plant of the United Illuminating Company, New Haven, Conn.

Six well pumps having a combined capacity of 600 gallons per minute draw water from underground and deliver it to a large sand-settling tank (Figure 4). From here the water flows over a weir, to which is connected an integrating meter, to a second tank. Another pump takes water from this tank and delivers it to one or more of eight water coolers, which are the evaporators of the refrigerating system. In these coolers, the water is reduced in temperature and is then discharged to the sewer. The heat removed from the water is raised in temperature and transferred to a closed hot-water-heating system by one or more of eight 40-horsepower, hermetically sealed, water-cooled condensing units. A pump in this water circuit circulates the water through the eight condensers in series and delivers the water to the air-conditioning units located throughout the building. After passing through all of the air-conditioning units, the water is returned to the first condenser.

It was stated that the condensers are connected in series. This was done to increase the coefficient of performance. With this arrangement, each condenser raises the water temperature several degrees, and only the end condenser is operated at the final condensing temperature and pressure. If the condensers were connected in parallel, each condenser would have to operate at a final condensing temperature such as to give the desired heating-water temperature.

The heating system was designed on the basis of delivering water 124 degrees Fahrenheit to the heating units when the outdoor temperature is 20 degrees. For outdoor temperatures below this value, the temperature of the heating water is increased, and reaches a maximum of 135 degrees when the outdoor temperature is zero. For temperatures above 20 degrees, the heating-water temperature is lower than 124 degrees.

Control of the condensing units is obtained through an outdoor compensated type of thermostat located in the heating-water circuit. This thermostat, through a step controller, turns on or off the condensing units as required. When a condensing unit is shut down, the water continues to flow through the condenser without any added heat, but the flow of water through the cooler is stopped.

When cooling is required, the equipment operates as a conventional summer air-conditioning plant, the cooled water from the evaporators being delivered to the air-conditioning units, and the condenser water discarded.

Summary of Operating Data. The data on the reverse-refrigeration plant of the United Illuminating Company here presented are for the heating season of from December 1, 1940, through March 31, 1941. The month of November 1940, is excluded because data are not available for the whole month.

Table II shows the hours of operation of the compres-

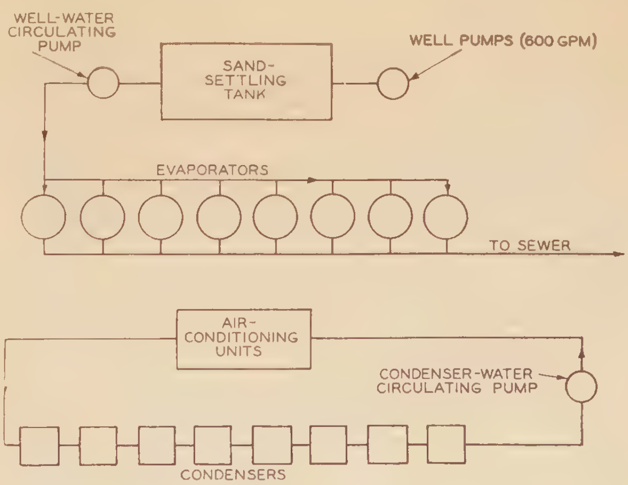


Figure 4. Heat flow in the United Illuminating Company plant

sors and the per cent of available compressor-hours versus degree-days. This table was compiled from the daily readings of hour meters. Provision is made whereby the sequence of operation of the compressors can be changed so that the hours of operation will be about the same for each compressor. The degree-days were obtained from the local weather bureau.

It might be inferred from Table II that the plant is oversized. This is not the case, however, because the full load is not imposed upon the plant 24 hours a day. Quite often the ventilation fan is in operation only during the day. This fan draws in a large volume of outside air representing a considerable portion of the heating load. Also, an additional heavy load is imposed upon the plant from the garage area when the doors are opened to allow the trucks and cars to depart and return. This traffic is heaviest during the morning and evening, although a considerable number of vehicles go in and out during the noon hour. This load is of such short duration, however, that it has little effect on the total hours of operation of the plant. For the heating season in question, the records show that the maximum number of compressors in operation at any one time was five.

In Table III are shown the gallons of water used, kilowatt-hours consumed, and the coefficient of performance for each month of the heating season. The amount of water used was obtained from daily readings of an integrating flow meter. The figures in the "temperature-difference" column were obtained from recording thermometer charts covering a two-month period. The temperature of the well water was found to be practically constant at $57^1/_2$ degrees Fahrenheit. The average temperature of the outlet water was found to be approximately 51 degrees, making a difference of 6.5 degrees.

Allowance is made for the kilowatt-hours consumed by certain auxiliary motors which would be necessary in a conventional heating plant. The figures in the "net" column of Table III, therefore, show the total power consumed by all of the apparatus required by the reversed-cycle heating plant, including well-pump motors, condenser-water-pump motors, and booster-pump motors. Power required by the ventilation fan is metered separately and is not included.

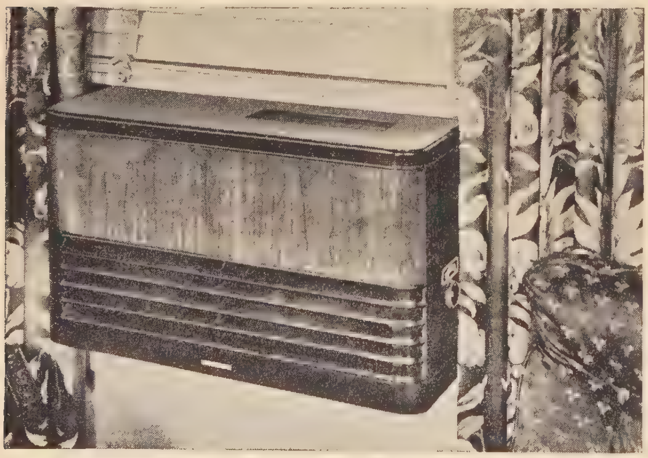


Figure 5. The Mobilaire

Table II. Compressor-Hours Operation and Per Cent of Available Hours Versus Degree-Days

Month	Compressor-Hours	Per Cent of Available Hours	Degree-Days
December 1940	1,470	24.7	912
January 1941	1,577	26.5	1,184
February 1941	1,282	23.8	985
March 1941	1,456	24.5	956

Table III. Coefficient of Performance for Heating Season

Month	Well Water Used (1,000 Gallons)	Temperature Difference Deg. F	Heat From Well Water (100,000 BTU)	Net Kwhr	Heat From Electric Energy (100,000 BTU)	Total Heating Effect (100,000 BTU)	COP
December 1940	10,380	6.5	5,620	81,915	2,800	8,420	3.00
January 1941	11,480	6.5	6,230	86,615	2,960	9,190	3.10
February 1941	9,460	6.5	5,120	77,780	2,660	7,780	2.92
March 1941	9,750	6.5	5,275	81,215	2,780	8,055	2.90

Calculation of the coefficient of performance is:

(Heat from well water) = (Gallons of well water) (temperature difference) 8.33

(Heat from electric energy) = (kwhrs) 3,415

$$COP = \frac{\text{(Heat from well water)} + \text{(Heat from electrical energy)}}{\text{(Heat from electrical energy)}}$$

The average coefficient of performance for the entire season is 2.98. This means that almost three times as much heat is obtained from this plant as would be obtained from direct resistance heating.

Residence Application. For residences and small offices a self-contained, portable heating and cooling unit known as the Mobilaire (Figure 5) has been made available. It can be installed in any standard window, requires neither water nor drain connections, and plugs into an appliance outlet. It has sufficient capacity to heat a single room with an outdoor temperature above 40 degrees Fahrenheit. Heating or cooling is selected simply by operating a special four-way valve. This new type of unit is mounted in the window so that one coil is outdoors and the other coil is indoors.

The heating capacity of this unit is 6,600 Btu per hour when the outdoor temperature is 60 degrees Fahrenheit and the indoor temperature is 75. The compressor motor draws 850 watts under these conditions, resulting in a coefficient of performance of 2.28. When used for cooling, this unit can cool at the rate of 6,000 Btu per hour with an outdoor temperature of 95 and an indoor temperature of 80.

Carrier-Current Relaying and Communication on the TVA System

M. STEPHENS MERRITT
ASSOCIATE AIEE

T. DEWITT TALMAGE
MEMBER AIEE

Carrier pilot relaying and carrier-telephone communication have been installed to meet the difficult requirements of relaying and intrasystem communication on the extensive Tennessee Valley Authority system. Eight power-line carrier-telephone channels which can be interconnected at many points and carrier pilot relaying on 20 high-voltage transmission lines help to expedite the multipurpose operating procedures of the TVA. This article gives reasons for the selection of carrier relaying and communication and presents an analysis of their application, of the difficulties encountered, and of their over-all performance under service conditions.

THE Tennessee Valley Authority was formed by an Act of Congress in 1933. The Wilson Dam hydroelectric plant, which was begun in 1918 as a national defense measure and completed in 1925 with an installed capacity of 184,000 kw, was turned over to the Authority. The Act creating the Authority made mandatory the immediate construction of Norris Dam and transmission-line connections between dams. This was to constitute a beginning of a complete development of the Tennessee River from its confluence with the Ohio River to its tributaries in the Great Smoky Mountains, a distance of approximately 600 miles.

The Tennessee River is formed by a junction of two main tributaries. Three other main tributaries join the stream within approximately 100 miles. All of these principal tributaries originate on the western slope of the Appalachian Mountains. This area has a high annual rainfall averaging approximately 120 inches, most of which occurs in a short period of time each year. The steep slope of the terrain results in very rapid run-off. The deep gorges through which these tributaries flow offered possibilities of immense water storage by means of high dams across the gorges. Storage of water within these gorges during the rainy season offered a means of flood prevention down stream. Subsequent emptying of the reservoirs would maintain stream flow in the lower reaches of the river during the dry months for navigation. The water could be used for power generation at the storage dams and at all other dams located downstream.

The main stream of the river system courses through the flatter area toward the Mississippi delta. This area has an annual rainfall of approximately 60 inches. The terrain necessitated that navigational developments be made by means of a series of comparatively shallow pools. A great amount of storage capacity was not required for flood control due to a smaller annual rainfall, a somewhat better distribution of this rain through the year, and the slower run-off of the water shed. Power generating plants at these low-head dams would be of the run-of-river type.

The development required that dams be designed and operated primarily for navigation and flood control, and that all power possible be generated by the water available, as long as it did not conflict with the primary purposes of the development. The disposal of the power generated would require the construction of high-voltage transmission lines to connect the hydroelectric generating stations with each other, to heavy load areas in the Tennessee Valley, and to interconnect with other electric utilities within transmission distance of the hydroelectric generating stations.

It was recognized that the limitations imposed by navigation and flood control on power generation at the tributary storage dams and on the run-of-river hydroelectric generating stations would necessitate the transmission of large quantities of power between the two ends of the system. During the rainy months when water would be impounded in the storage reservoirs for flood prevention and for later release for navigation, most of the loads in the eastern area would be supplied from the run-of-river hydroelectric generating stations downstream. During the dry season when water would be released from the storage dams, the generation from the downstream hydroelectric generating stations would be at the minimum for the year; and the long-distance power transmission would be reduced. These seasonal peak loadings expected on transmission circuits between the storage and run-of-river hydroelectric generating stations would require these circuits to be loaded at times to a value near their steady-state stability limit; otherwise, a considerable investment would be made in transmission capacity which would be utilized only a portion of the year.

Satisfactory operation of such a transmission system was not to be expected, unless any fault which should occur on a transmission line and which might result in

Essential substance of a paper presented at the AIEE Southern District meeting, New Orleans, La., December 3–5, 1941.

M. Stephens Merritt is relay and protection engineer, department of power operations, and **T. DeWitt Talmage** is communications engineer, department of power engineering and construction, both with Tennessee Valley Authority, Chattanooga, Tenn.

instability under critical loading conditions was disconnected in a very short time. Initial studies on the network analyzer indicated that faults on the principal 154-kv transmission circuits, involving all three phase conductors, must be disconnected from the system within ten cycles on a 60-cycle basis, and that faults of any nature on these transmission circuits, excepting single phase-to-ground faults, must be disconnected within 12 cycles. The oil circuit breaker selected for use on the 154-kv transmission system were of eight-cycle interrupting time. This imposed a limitation on the selection of protective relays, in that the relays must operate to close contact upon the occurrence of a three-phase fault in two cycles or less, and for any type of fault in four cycles or less. This operating time could be met only by the use of instantaneous relays in combination with some means of comparing the terminal conditions at the ends of the line by a pilot circuit. The use of carrier signal superimposed on the protected line offered the most reliable means of comparing terminal conditions, since the continuity of the blocking circuit would be substantially the same as the line to be protected.

The dispatching operation at the various dams and on the electric transmission system would require heavy communication traffic which, together with the long distances involved, presented a large problem in the supplying of communication facilities. To maintain reliable and continuous communication with dams and switching stations at isolated locations, more than one method or routing of communication channels would be necessary. The use of the power lines for a part of the communication system was indicated by requirements of economy and speed of establishing contacts between stations, and by the fact that hazards to carrier and wire circuits were so dissimilar that a combination of both would give the most nearly continuous service.

Provision was necessary for the transmission of metering impulses from the interconnection points to various hydroelectric generating stations, so that maximum flexibility in operation could be obtained by tie-line load regulation. A feasible method for accomplishing this consisted of utilizing the carrier facilities for the transmission of these impulses in common with other uses. The facilities necessary for carrier communication, pilot relaying, and telemetering are similar. Obviously, one could expect economies in engineering, construction, maintenance, and operation by considering these allied carrier functions as a single problem.

All relaying schemes available for protection of long transmission lines use a three-phase potential source for their operation. The combined use of capacity coupling for connection to the transmission conductor of high-frequency circuits for communication, relaying, and telemetering, with the further use of the coupling capacitor for a secondary potential source,[1] offered additional inducement for the selection of carrier channels as the primary means of communication, relaying, and telemetering over the longer circuits.

The growth of the power system has followed very closely the basic ideas for development of the area and interconnection with other utilities. The 110-kv and 154-kv lines, constructed and in service as of September 1, 1941, total 2,386 miles. The hydroelectric generating capacity in service as of this date was 838,000 kw. The salient points in the basic plan of this transmission system are:

1. Two 154-kv lines located on separate rights of way connecting the run-of-stream hydroelectric generating stations on the Tennessee River.

2. The 154-kv lines connecting hydroelectric generating stations on the tributaries to the main river system.

3. High-voltage transmission circuits to concentrated load areas and interconnections with other electric utility systems.

Carrier pilot relays are used on the power transmission lines of this system, and the line conductors are used to establish carrier channels for communication and telemetering in order to gain the advantages of multiple use of equipment in the manner outlined below:

1. Pilot relaying is used on all 154-kv tie lines of the primary system with one exception, which will probably be converted in the immediate future to carrier operation. Several of the 110-kv transmission lines which are used as principal tie lines are equipped with pilot relaying. Carrier is used for the pilot circuit on longer lines.

2. With few exceptions, the hydroelectric generating stations and principal switching stations have both carrier and metallic-circuit communication channels provided. The exceptions are stations where the short distances to the system load-dispatching office and the availability of several separately routed metallic channels insure reliable communication.

Table I. Summary of TVA Power-Line Carrier Systems

September 1941

	Pilot Relay	Communication
Number of carrier sets	43*	30**
Number of carrier channels	20	8
Number of carrier frequencies	15	9
Average number of carrier sets per channel	2.05	3.7
Shortest carrier channel in miles	15.5	149
Longest carrier channel in miles	220	283
Average length of carrier channel in miles	62	173
Total length of carrier channels in miles	1,240*	1,384
Total miles of channel used in conjunction with telemetering	195	0
Total miles of channel equipped to provide point-to-point emergency communication	1,045	0
Total number of set-years operation	103	86
Average supply power input in watts	255	975
Minimum carrier power output in watts	15	10
Maximum carrier power output in watts	30	150
Average carrier power output in watts	29	78
Average number of vacuum tubes per set	7	33
Number of coupling capacitor assemblies	43	76
Number of line tuning units	43	40
Number of line traps	43	72

* Two of these sets are on channels jointly owned with interconnecting power companies. Channel mileage is not included for these two tie lines.

** Mobile and portable communication sets not included.

3. Both metallic circuits and carrier channels are used for telemetering. All carrier installations are made so that the telemetering function can be added to existing equipment with minor changes. This addition would use either the relay blocking channel or a separate frequency on the line.

4. All coupling capacitors used in the relay carrier channels also function as a part of a resonant potential network.[1] These are used as line potential sources for synchronizing and voltage indication. The two coupling capacitors used in the carrier-communication channels are used also as a part of resonant-frequency-potential sources in many cases which—in combination with the one source from the relay capacitor—furnish three-phase potential for relays and instruments.

Table I shows the extent to which carrier channels have been used on the system.

I. CARRIER RELAYING

The data on carrier relaying contained in this article are intended to show why it was selected, its application to various circuits, some of the earlier difficulties encountered, and its over-all performance under service conditions. No attempt is made to discuss the technical aspects of different circuits which have been used in both the protective relay and blocking channels.

Several different types of equipment were available from various manufacturers at the time the initial installation was made. All of these types were similar to the extent that the carrier circuit was held ready for instantaneous service, to start the blocking signal immediately upon operation of instantaneous fault-detecting relays at a line terminal; carrier transmission over a circuit was stopped by operation of directional relays, indicating that fault condition was internal to the line; and the initiation and removal of a carrier signal—without the instantaneous fault-detecting relay having reset—established a tripping circuit to breakers at all line terminals. The tripping circuits could be set up in a lapsed time from the inception of a fault of 0.75 to 4 cycles. The relaying equipment consisted of the following general types, each of which could be supplied with out-of-step blocking features, if desired:

1. A combination of especially designed impedance relays and directional units for carrier-frequency application. These were faster in operation, but they did not have provision for tripping of the circuit breakers, in the event that carrier-controlled relays were inoperative because of the nature of the disturbance or the failure of equipment.

2. Conventional distance relays, wherein a carrier-frequency signal or other signals were used to operate a device which, in effect, by-passes the definite time imposed in tripping by distance relays on a backup zone. These were slower in setting up the tripping circuit than the relays especially designed for carrier use.

Relay Installations. Figure 1 shows the main 154-kv transmission circuits which are supplied with pilot protection, either by means of telephone conductors or carrier-frequency channels. This transmission diagram shows the length of each line, the maximum load which has been transmitted over the lines for an appreciable period of time, and code symbols designating the type of relays used for each line terminal. The code is as follows:

A—Phase impedance and directional units, together with an instantaneous and a directional overcurrent unit for ground protection, all especially designed for carrier use. Backup protection consists of directional ground relays and phase overcurrent relays,

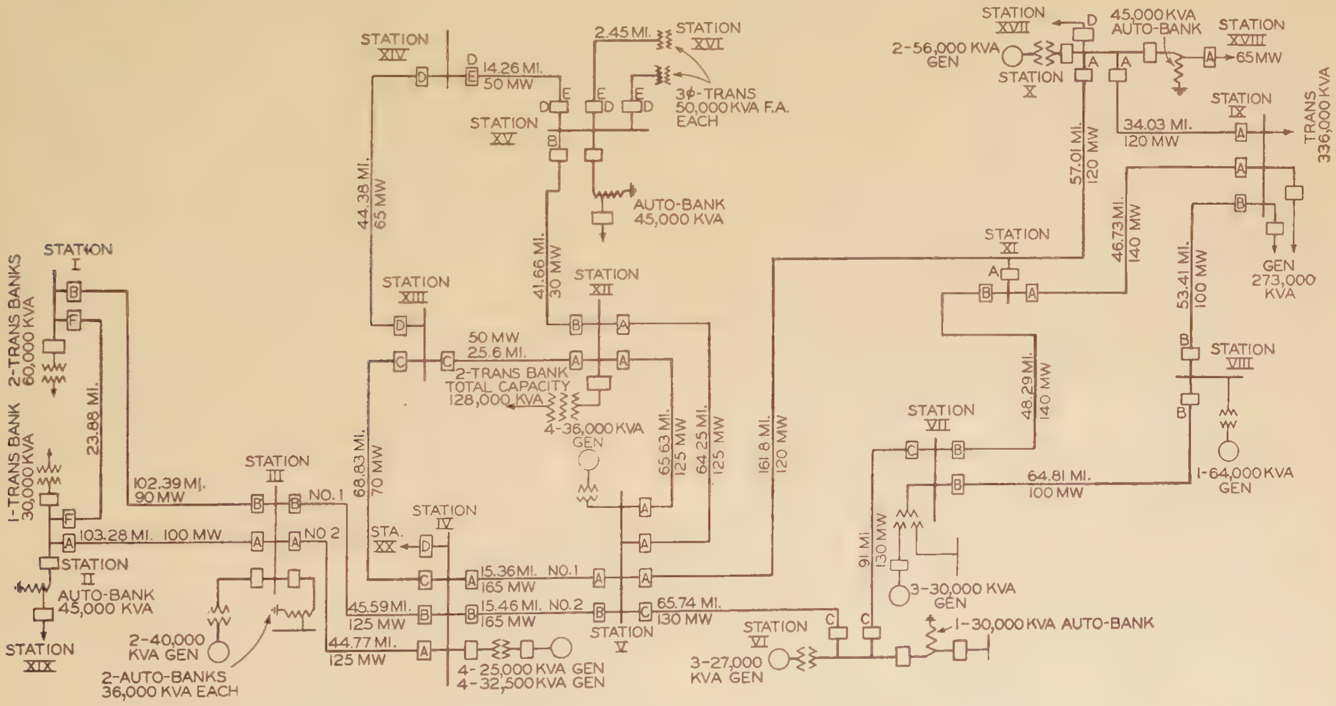


Figure 1. Diagram of 154-kv transmission system showing location of the five different applications of pilot-relay protection

containing both instantaneous and induction elements, which are directionally controlled when necessary. Transmission of carrier is started by the opening of contacts on an impedance element or the instantaneous ground element, and is stopped by operation of the phase or ground-directional unit. Out-of-step blocking is accomplished by holding carrier on continuously during a three-phase disturbance which originated external to the line.

B—Standard three-zone impedance relays for each phase, together with a ground element consisting of two high-speed overcurrent units and a ground-directional unit. Transmission of

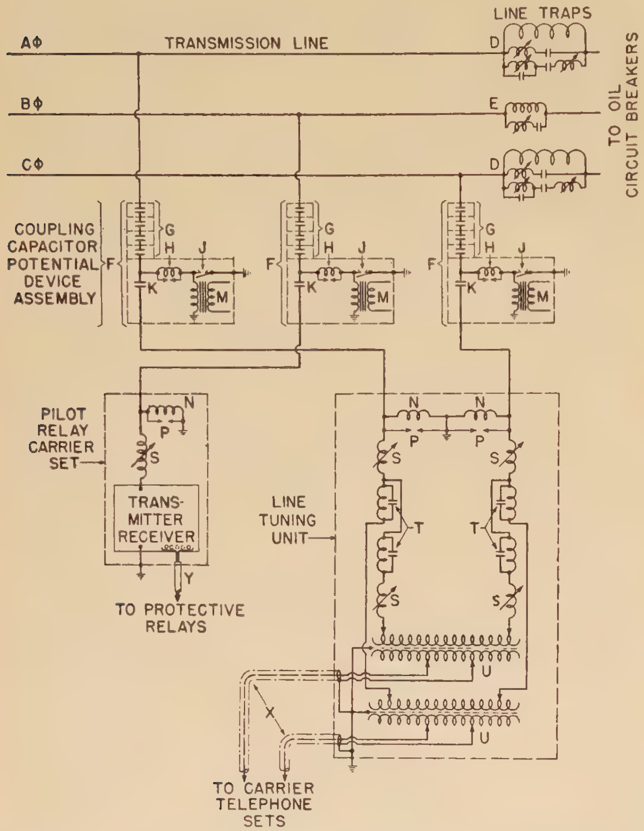


Figure 2. Typical carrier terminal diagram showing coupling of one relaying and two communication channels

D—Two-frequency line trap
E—Single-frequency line trap
F—Coupling-capacitor potential device assembly
G—Coupling capacitors
H—Carrier-frequency choke coil
J—Grounding switch and protective gap
K—Auxiliary capacitor
M—Potential transformer
N—60-cycle drainage coil
P—Protective gap
S—Line-tuning inductance
T—Carrier-frequency traps
U—Impedance matching transformer
X—Coaxial lead-in cable
Y—Multiconductor control cable

carrier signal is initiated by the closing of the third-zone contact or the instantaneous ground overcurrent element. It is stopped by the operation of the ground-directional element to the "closed" position or by the setting up of the trip circuit by the second zone of the distance relays. Backup ground protection is obtained from conventional directional ground relays and the normal operation of the distance relays. Out-of-step blocking functions to open the trip circuit from the phase elements of carrier relays a definite time after a three-phase fault occurs, and is maintained open until the three-phase disturbance has subsided.

C—Three-zone reactance relays using a separate set of phase impedance units for the starting of carrier, and a ground element consisting of two high-speed overcurrent units and one high-speed directional unit. Transmission of carrier is initiated by the opening of the contacts of the separate impedance units, or by the opening of the instantaneous element of the ground relay. It is stopped by the operation of the high-speed ground directional or phase directional unit of the distance relay. Tripping results from the closing of the high-speed induction overcurrent element of the ground unit or the ohm units of the distance relays used for carrier protection. The receiver relay of the carrier system, in effect, by-passes the operation of the timer for this ohm unit. Out-of-step blocking is established by the development of a three-phase fault external to the line. It is maintained during the disturbance by opening the trip circuit from phase carrier or continuing the carrier signal. Backup protection is obtained by the normal functioning of the distance relays and by a conventional directional ground relay.

D—Conventional reactance relays and directional ground relays. No pilot blocking at any time is used.

E—Three-phase voltage-restrained directional relay in combination with a high-speed directional ground relay. Continuous blocking is obtained by means of a telephone conductor circuit and the station storage battery.

F—Three-zone impedance relays as described for carrier use in *B*, except that blocking is obtained by means of a telephone circuit and actuated by potential from station storage batteries.

It is to be noted that carrier blocking is used on all of these lines rather than metallic circuits, except where a shielded cable is available between the two line terminals, and where the annual cost of the relays and the cable is competitive with the annual cost of the equipment necessary for carrier protection.

Carrier Terminal Equipment. The installation at each terminal of the line consists of a high-frequency transmitter and receiver unit, a coupling capacitor between the transmitter–receiver unit and the transmission line conductor, and a line trap located between the station bus and the coupling capacitor. This equipment is in addition to the protective relays for the circuit. This terminal equipment is shown diagrammatically in Figure 2 and photographically in Figure 8. It is described briefly in the following paragraphs.

The transmitting, receiving, and surge protection equipment is assembled in an outdoor cabinet, is usually located adjacent to the coupling unit, and is designed for operation at any selected frequency between 50 and 150 kilocycles. It utilizes one transmission-line conductor and ground return for its circuit. The photograph, Figure 3, shows the typical arrangement and mounting of this equipment.

The transmitters are supplied from the station storage battery or from a rectified a-c power source. The rectifying equipment, where used, is contained within the set. The set consists of an oscillator and amplifier with sufficient power output to produce a reliable signal at the remote receiving equipment. The oscillator circuit is held inoperative normally. It is released for oscillation by the operation of the protective relays, by

telemetering equipment where such is used, by controls from emergency carrier-telephone attachment, or by the test button. The transmitters are controlled by one of the two following methods:

1. Removing a high negative bias from the grid circuit by the opening of the protective-relay contact or other contacts associated with telemetering, testing, or emergency telephone equipment.

2. Changing the potential supply in the plate of the oscillator tube by the closing of contacts in the protective relays, telephone equipment, test button, or telemetering equipment.

The receiving element consists of a detector circuit and sufficient amplification to maintain a reliable signal output during the most unfavorable conditions for carrier transmission over the power conductor from the remote transmitter. A drainage circuit is provided, so that a maximum limit is placed on the signal supplied to the receiver relay. The receivers are selective, to the extent that erroneous operation will not result from another signal spaced five kilocycles or more from its adjustment.

The capacitors used for carrier coupling consist of several units in series, rated for phase-to-neutral voltage of the power system. A tap between sections of the capacitor stack supplies energy to a medium-voltage potential transformer through a carrier-frequency choke.

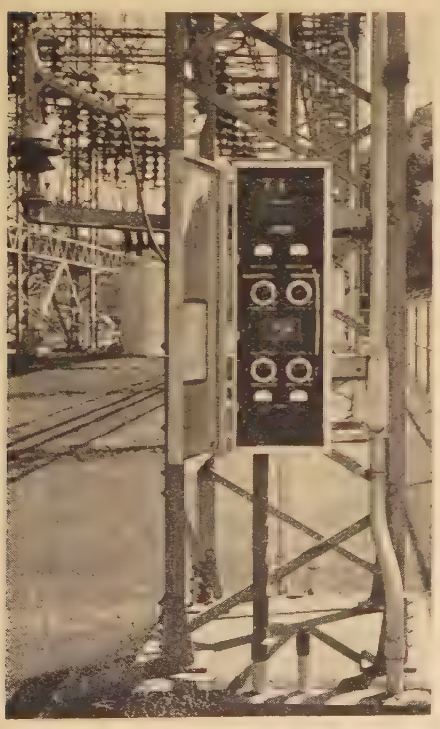


Figure 3. Typical carrier - relaying transmitter - receiver set

This potential transformer, together with adjustable inductance and capacitance, supplies a 60-cycle 69-volt or 115-volt potential source which is inphase with the primary phase-to-ground potential. This unit is used to supply potential for synchronizing and—in combination with other similar units where carrier communication is installed—for potential to protective relays and meters.[1]

Line traps are used to prevent the carrier channel from becoming short-circuited during an external phase-to-ground fault, and to block effectively the flow of energy of the carrier frequency or frequencies from the station bus—thus confining the output of the transmitter to the circuit to which it is connected. The use of these devices reduces the power required to maintain an effective blocking signal and, at the same time, prevents energy at or near the tuned frequency of the circuit from entering from another circuit. The same frequency can be used on several transmission lines as long as the lines are physically located so that there is no interference because of coupling between them. The inductive component of the line traps consists of power conductors, with current-carrying capacity equal to that of the line, wound on a porcelain cylinder. Adjustable capacitors are used for tuning and are mounted inside the porcelain cylinder. The capacitor units are made watertight, and the ends of the porcelain cylinders are covered over in such a manner as to prevent the entrance of birds.

Application Problems Encountered. After the installation of the first few units of carrier relays, tests were made to check this equipment by placing faults within and external to carrier-protected lines. These tests were arranged to represent, as nearly as possible, actual fault conditions, by using arcing faults rather than solid metallic faults, and by using a separate oil circuit breaker to connect a fault to the line. The tests disclosed certain conditions under which satisfactory performance was not obtained. Some of these conditions resulted from the inability of the instrument transformer secondary circuits to portray accurately the conditions on the primary line. The instrument transformers supplying the relays were, in all cases, bushing-type current transformers. Both station-type potential transformers and coupling-capacitor potential networks were used for potential supply. The difficulties encountered and the remedies used for their elimination are summarized briefly as follows:

1. The resonant-circuit potential device[1] under fault conditions would oscillate, producing a very unstable voltage, both as to magnitude and frequency. The output from these devices contained harmonics of a high order and of a very great magnitude. It was also found that, when energizing an unfaulted line section, normal secondary potential was not re-established so fast as current was built up in the current-transformer secondary circuit. These difficulties were eliminated by rebuilding the potential devices to obtain stable performance under all normal conditions and with any secondary burden in the range for which the device was calibrated. The carrier-relay directional-unit circuit was modified to some extent and adjusted to prevent tripping of the oil circuit breaker by these relays when energizing an unfaulted line.

2. It was found that the unsymmetrical pole opening or closing of an oil circuit breaker, which results in establishing or maintaining a tie for a short interval of time as a two-phase and neutral or single-phase and neutral connection, would cause operation of the carrier equipment. This condition, of course, is identical on a grounded wye system with an internal phase-to-ground fault on

the line. This was eliminated by the use of an overcurrent induction element in the ground trip circuit so that a minimum of approximately two cycles was required to trip by carrier ground relay.

3. It was found that the energy emitted from the arc caused by opening an oil circuit breaker carrying heavy current could adversely affect the received carrier signal to such an extent that it would be destroyed. This permitted incorrect tripping of an unfaulted circuit adjacent to one wherein the oil circuit breaker was disconnecting a faulted line. This defect was corrected by the addition of an auxiliary relay which functioned to prevent the operation of the receiver relay on loss of carrier signal after carrier had been received continuously for approximately four cycles. The auxiliary relay would then release the receiver relay for tripping after a definite time of approximately four cycles. This unit does not interfere with the normal performance of carrier for an internal fault; but, in the event of an external fault, carrier is made inoperative by the time arcing begins in a breaker and is held inoperative for sufficient time to override arcing within the breaker. The carrier-receiver unit was readjusted, and its surge protection was modified to minimize the likelihood of detuning the circuit.

Similar conditions could be obtained by the opening of air-break switches; however, the likelihood that an air-break switch operation would occur coincidental with a fault is so remote that the readjustment of the receiver equipment was considered satisfactory for the elimination of this possibility.

4. It was found that operation of air-break switches on a high-voltage bus also caused a momentary drop in potential, supplied from a resonant-circuit potential device. This reduction in voltage did not last for more than $1^1/_2$ cycles, but it was of such magnitude at times as to cause incorrect tripping by carrier relaying on a heavily loaded line. The only remedy employed for this purpose was to maintain settings of the carrier relaying high enough to minimize the possibility of such occurrence.

Investigations and operating experience also revealed conditions which necessitated some modification in equipment. On long circuits, like the line between stations V, XI, and X, it was found that, where a combined phase and ground-directional element was used, it was necessary to remove all phase torque, as well as restraint, from the phase unit in order that the element could operate properly. The charging current for the line exerted more torque on the phase unit than did the ground unit for a metallic ground fault at the remote end of the line.

It was also found undesirable to have complete ground preference to the extent that tripping by phase relays was prevented after carrier was initiated by the ground element. Multiple phase and ground faults may have a value of ground current sufficient to start carrier by the ground element but insufficient to trip by the ground element. This condition was overcome by rearranging the circuit so that a ground-directional element, as sensitive in setting as the element which started transmission of carrier, would release ground preference for tripping either by the ground-tripping overcurrent element or the phase relays.

It has also been found that, because of the characteristics of bushing-type current transformers and the necessary secondary leads and wiring, a residual current may be present during an interphase fault not involving ground. At times, this residual current is of such magnitude as to start transmission of carrier. A ground-directional element is inoperative for removal of carrier under this condition. This problem is being studied in an endeavor to eliminate this condition. Figure 4 shows an oscillogram taken when closing into an ungrounded fault between two phase conductors. The residual current in the ground carrier-starting element shown on trace 4 was of sufficient magnitude to start and maintain a carrier-blocking signal for several cycles. On similar test, but without complete oscillographic information, the line breakers did not trip during the fault.

Performance Record. The initial carrier installations were made in 1937 on the IV-V and the V-XI-X lines. Additional terminals have been placed in service at frequent intervals since that time, as shown in Figure 7. The operating record of this equipment submitted in Table II is limited to that period between January 1, 1939, and September 1, 1941. The small number of terminals in service prior to 1939 and the limited oscillographic information preclude the inclusion of earlier operations in a detailed analysis of equipment performance.

Automatic oscillographs are in use at most of the hydroelectric generating stations. These are connected in such a manner as to obtain the maximum amount of information on the performance of carrier relaying on the main 154-kv transmission circuits. The data given in the tabulation on the type of fault, its location, and the performances of relays on internal and external faults, were deduced from the automatic oscillograph records.

The symbols given in Table II for causes for incorrect performance on internal faults are explained as follows:

A. The fault was cleared at both terminals by backup relays. The failure to trip by the carrier-blocked high-speed relays was found to have resulted from incorrect connection of the ground-directional element. Ground preference prevented operation by the carrier phase relays.

B. A broken wire within the relay and inside the insulation was found subsequent to the second incorrect tripping. This broken lead was in such a position that tripping by the carrier-controlled elements was prevented. The faults were cleared in both cases by backup relays.

C. A three-phase fault was cleared at both terminals by backup distance relays. A carrier-blocking signal was maintained throughout the fault. No transformer neutral current was present. It was concluded that failure to trip properly resulted from the operation of the ground carrier-starting element, because of characteristics of the bushing current transformers and their performance under fault conditions. This possibility was verified by staged tests. The oscillogram, Figure 4, was taken during these tests.

D. Maladjustment of two circuit contacts prevented the removal of carrier-blocking signal. The fault was cleared by backup relays.

E. The fault was from two-phase conductors to ground near station XI and was cleared by backup ground relays. It was

deduced that failure to trip by the carrier relays resulted from insufficient torque to close the contacts of the potential-polarized ground-directional unit at station IX terminal, even though the ground current was of sufficient magnitude that the ground element for starting carrier would pick up. The ground preference held the carrier phase elements inoperative. This case may have been an operation similar to *C*.

F. A three-phase-to-ground fault, wherein the magnitude of ground fault current in the fault started transmission of carrier by

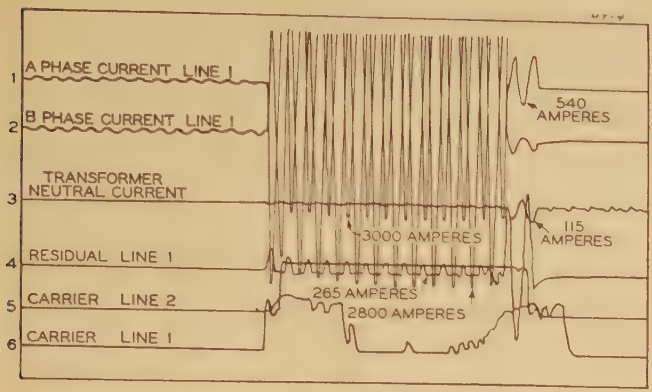


Figure 4. Oscillogram taken during staged tests at station III

Trace 4 is the residual current circuit from bushing-type current transformers located in the faulted line oil circuit breaker. Trace 3 shows the absence of ground current during the fault. The fault was cleared by the test breaker by means of overcurrent relays. Carrier blocking was not removed from the faulted line until approximately five cycles after the fault was started, as shown on trace 6. Both terminals of the line tripped correctly after the time delay

the ground element, but did not result in tripping by the ground element. The ground-preference characteristic prevented the tripping by the phase elements.

G. A permanent single-phase-to-ground fault between the overhead ground wire and *A* phase conductor failed to trip by the carrier-controlled relays. The load and charging current on the line were such that a combination phase and ground-directional relay did not operate to remove carrier blocking and permit tripping. The fault was cleared by backup ground relays. The oil circuit breakers were not tripped simultaneously.

H. Two faults occurred in the same afternoon on the line. Each was tripped correctly at one terminal by carrier relay operation. The other terminal was cleared in each case by the operation of backup relays. The failure to trip properly at the second terminal was found to have resulted from mechanical trouble in the auxiliary seal-in unit of the carrier relay.

The symbols in Table II for causes of incorrect tripping on external faults are explained as follows:

(*a*). Both ends of the line were tripped simultaneously with an external ground fault. The ground-directional element at the adjacent terminal was found to be connected incorrectly. The incorrect connection resulted from temporary wiring used while additions were being made at the locations involved.

(*b*). Incorrect tripping occurred at the end remote from an external fault. A line trap was subsequently found to have caused a received carrier signal below the operating level of the receiver relay. The line-trap failure resulted, in one case, from condensation within the tuning-capacitor unit and, in the other, from wet birds' nests which short-circuited the tuning-capacitor unit in the trap.

(*c*). Operation by all three-phase elements on an out-of-step condition. The electrical center of the disturbance was just beyond the remote terminal of the line. No definite cause for this incorrect operation has been established.

(*d*). Defective resistor, in the receiver relay at the terminal remote from the fault, prevented the carrier signal from holding open the receiver-relay trip circuit.

(*e*). Tripping circuit was apparently set up during arcing of the breaker on an adjacent section, since tripping on this line occurred slightly later than on the faulted line.

(*f*). The breaker at one line terminal was tripped by differential-relay operation on a fault within the station. The remote end of the line was tripped immediately following the opening of the first breaker (by differential relay) at the remote station.

(*g*). The end of the line remote from a three-phase external fault was tripped immediately through the second zone of distance relays, despite carrier blocking. Subsequent investigation revealed that the timer for this zone was stuck in the "closed" position. It was concluded that a previous disturbance, external to the reach of this zone, had caused operation of the timer which failed to reset. The type of contacts was changed to a different design to prevent recurrence.

(*h*). These operations took place on power swings following faults. They probably should not be charged to the protective relays as incorrect performance, since the application, rather than the equipment, is the cause. From the length of line and loads transmitted, it is obvious that very little difference exists between load impedance and fault impedance. Since the line has three terminals, a tripping value can be reached at station V terminal on power input, before the output from the line at either station XI or X will cause transmission of carrier. This line will be broken at station XI when the permanent switchyard at this point is placed in service.

Remedial measures have been worked out in conjunction with the manufacturers and put into effect; these should eliminate most of the incorrect operations resulting from malperformance of carrier-blocking channels, of relays as applied to the transmission circuit, and of instrument transformers in portraying the transmission-line conditions to the relays. The backup distance relays are now connected in such a manner that out-of-step blocking does not affect their operation, and all zones are normally in service at all times. The incorrect connections, which resulted in failure to trip on internal faults and in incorrect tripping on external faults, were temporary connections, used while extensions or changes were in progress at the stations involved.

Conclusions. The results obtained from the carrier relays have well justified their selection. The critical loading of transmission circuits, due to recent abnormal loads and drouth, has clearly demonstrated the necessity for high-speed clearing of the main transmission circuits during faults, if instability is to be avoided. In addition, it has been demonstrated that lower-voltage transmission or primary distribution circuits, in many cases, must be equipped with some form of protection which will clear a fault on any portion of these circuits within a very few cycles.

Based on the experience recorded in this paper and under the existing system requirements, the following

statements appear to be justified. The original assumption that the carrier channel over the power conductor was substantially as reliable as the transmission line has been proved correct. The elimination of conditions which caused detuning of line traps, loss of blocking signal—due to the arc during the opening of an oil circuit breaker on a fault, and rigorous maintenance of the transmitter–receiver equipment will remove, it is believed, further difficulties from the blocking channel.

The performance of distance relays as backup protection and of the backup ground relays has been of great value in disconnecting a faulted line, when carrier equipment was not available for service due to maintenance and repair, during out-of-step conditions, or when the carrier relaying failed to operate properly. It has been determined that the distance relays with carrier blocking are more satisfactory than the especially designed carrier units which do not include backup phase protection, unless separate distance relays are used for this purpose. These distance relays should be in normal service at all possible times and should have no restriction in their performance by out-of-step blocking. Should the electrical neutral of an out-of-step condition develop within the reach of zone 1 of the distance relays, the immediate disconnection of this circuit is preferable to a continued out-of-step condition on the system.

Table II. Operating Record of Carrier Relays

January 1939 to September 1941

Tie Lines between Stations	Date in Service	Faults on Lines: Total	3-Phase	2-Phase-to-Ground	1-Phase-to-Ground	Incorrect Internal: No.	Per Cent	Cause	Incorrect External: No.	Cause
III to II	July '38	2	0	1	1	2	100	*A*(2)	0	
III to I	June '40	3	0	0	3	0	0		0	
IV to III—No. 1	May '40	3	1	0	2	1	33	*B*	1	*a*
IV to III—No. 2	Feb. '40	2	1	0	1	1	50	*C*	0	
IV to XIII	Jan. '41	7	2	2	3	0	0		0	
IV to V—No. 1	Mar. '37	2	1	1	0	0	0		0	
IV to V—No. 2	July '40	0	0	0	0	0	—		0	
V to XII—No. 1	Mar. '40	2	0	0	2	0	0		0	*b*
V to XII—No. 2	June '38	5	2	2	1	1	20	*D*	1	
V to VI	Dec. '38	15	2	5	8	1	7	*C*	1	*a*
XI to IX	Nov. '38	6	3	2	1	3	50	*E*	1	*c*
VII to XI	Apr. '39	5	2	1	2	1	20	*F*	4	*a, e, f, d*
V to XI to X	Mar. '37	5	1	1	3	1	33	*G*	8	*g*(1), *h*(7)
VIII to IX	Aug. '41	0	0	0	0	0	—		1	*f*
IX to X	Nov. '38	3	0	2	1	0	0		0	*o*
X to XVIII	July '40	2	0	1	1	0	0		1	*f*
XII to XIII	June 38	2	0	0	2	2	100	*H*	0	*o*
XII to XV	Feb. 41	1	0	0	1	0	0		0	*o*
VII to VI	Dec. '38	15	4	6	5	0	0		1	*b*
VII to VIII	Sept. '40	2	0	1	1	0	0		0	*o*
Total 20 Lines		82	19	25	38	13	16		19	

The 16 per cent incorrect performance of the carrier relays on internal faults, as shown in Table II, is rather large. The failure to trip on internal faults, as a result of incorrect connections, contact adjustments, or mechanical troubles, should not be charged to the carrier-relaying scheme. The elimination of these failures as incorrect performance of the carrier scheme will reduce the number of tripping failures to 8.5 per cent. The removal from the incorrect column of those tripping failures resulting from defects that have been eliminated will further reduce the number of incorrect operations to 2.5 per cent.

Each fault listed in Table II and many others not listed were external to several carrier-protected lines. The definite percentage of operation on external faults which was correct or incorrect cannot be given. If the number of incorrect operations on external faults is reduced to those resulting from failure of the blocking circuit or the relay to function in accordance with the intended operation, the percentage operations which are incorrect will be very small. The modifications of the equipment which have been made to eliminate the recurrence of several of the remaining incorrect operations should result in a performance record that will be the equivalent of any other form of relaying now in use for transmission-line protection.

II. CARRIER COMMUNICATION

There are eight power-line carrier-telephone channels which furnish part of the primary communication service used to expedite operation of the multipurpose dams for flood control, navigation, and power generation. Direct communication channels between key generating and transmission stations provide fast service, and a sufficient number of stations have access to individual channels for efficient utilization of the facilities. Communication reliability is improved by routing circuits over different geographical paths between the same points, by utilizing various types of telephone systems, or by employing different kinds of outside plant facilities. Conditions which cause interruptions in one route, type, or kind of facility do not necessarily affect adversely the service rendered by another, since each possesses different inherent characteristics. A combination of these several methods is used to maintain contact between important operating points. Duplicate carrier-telephone channels are provided between a few important points. Separate transmission lines are used to establish these circuits.

The Tennessee Valley Authority is operating 1,384 miles of carrier-telephone channels and 2,000 miles of open-wire and cable telephone circuits. While much of the general communication service is leased from commercial telephone companies, the power-line carrier-telephone and the wire-telephone systems, which have been closely co-ordinated with each other, furnish the principal means of communication for carrying on multipurpose operations. Each of these several types of communication systems is arranged to supplement the others. These communication circuits are used primarily for interconnecting the various dams, hydroelectric generating stations, switching stations, and load-dispatching offices.

Table I includes data on the carrier-communication network, arranged for comparison with the pilot-relay carrier system.

The arrangement of 30 carrier-telephone sets, connected to eight separate channels (shown in Figure 5), was determined after a study which considered the balance between the reliability and flexibility needed, and the cost of the resulting layout, including the necessity for quick communication between related points in any one area, and provisions for extending the communication system to additional locations. There are approximately 100 telephones directly connected to the 30 carrier-telephone sets. These telephones serve strategic operating locations in the hydroelectric generating stations, such as the control rooms, superintendents' offices, repair shops, and telephone equipment rooms, as well as substation control buildings, offices of division managers and engineers, and district operating superintendents. Control rooms in the hydroelectric generating stations are provided with key-type telephone switchboards to which are connected the carrier-telephone sets and other communication circuits, all of which may be interconnected at these points.

Communication traffic studies are made at intervals to check the adequacy of the communication system and to insure maximum economy in use of the facilities. Electric timing and counting apparatus provides traffic data automatically on each carrier-telephone channel.

Types of System. Two basic types of carrier-communication equipment are used: one called "single-frequency duplex," or "single-frequency automatic simplex,"[1] by respective manufacturers, and another "two-frequency duplex." The single-frequency system uses one carrier frequency for both transmission and reception, while the two-frequency duplex, as its name implies, uses two carrier frequencies.

There are 28 single-frequency sets in use. These sets provide party-line use of the channel, which enables the system load dispatcher to communicate with a number of stations simultaneously, in effect providing a conference connection between the dispatcher and all stations involved, during switching or other operations. Complete control and operation of the single-frequency duplex communication sets are secured from two-wire, dial-type telephones. Voice and carrier signal-actuated relay circuits automatically control the operation of the transmitter and receiver circuits so that transmission of a carrier signal takes place only when voice, dialing, or ringing signals are actually being transmitted. During transmission, the telephone is connected only to the transmitter, and the receiver is blocked. During reception, the telephone is connected only to the receiver so that the transmitter cannot be operated. This automatic voice control of the sending and receiving functions uses electronic relays having no moving parts[3] in seven carrier-telephone sets and a standard telephone-type mechanical relay in the remaining sets. The over-all similarity of the two general types of single-frequency duplex equipment is so close that sets from two manufacturers are now being operated on a common carrier-telephone party-line channel.

The two-frequency system uses one frequency for transmission and reception in one direction, and the other frequency is used for transmission and reception

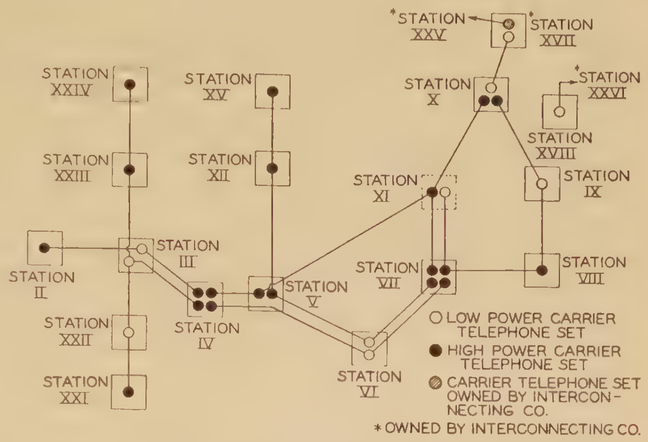


Figure 5. Carrier-telephone channels in operation on the high-voltage transmission lines

in the opposite direction. Both frequencies are continuously transmitted when the sets are in operation. Complete control and operation of the equipment are achieved by using local battery telephones.

The carrier power output of the telephone sets, shown in Figure 5, can be grouped in two general classes. The low-powered sets range from 10 to 25 watts, while the high-powered sets range from 100 to 150 watts. In the case of the single-frequency equipments, it is only necessary to install or remove an amplifier unit in the bottom of the cabinet in order to change the rating of the set from low to high power or vice versa. This unit-type assembly is desirable, since it provides the necessary flexibility for conveniently making changes in the carrier power output of individual sets. One installation of four carrier-telephone sets is shown in Figure 6. The two middle sets are single-frequency duplex equipments having a carrier output of 100 watts each, while the sets on each end are automatic simplex equipments having a carrier output of 150 watts each.

The carrier-communication and carrier-relay systems were installed in several major steps over a period of five years, as shown in the progress chart in Figure 7, which is based on the initial date each carrier unit was placed in operation.

Method of Operation. Each single-frequency duplex carrier-telephone set is equipped to provide six separate selectively rung telephone circuits. This has the advantage of providing more rapid inward and outward service to these points, because it eliminates manual operations by the station operator which normally would

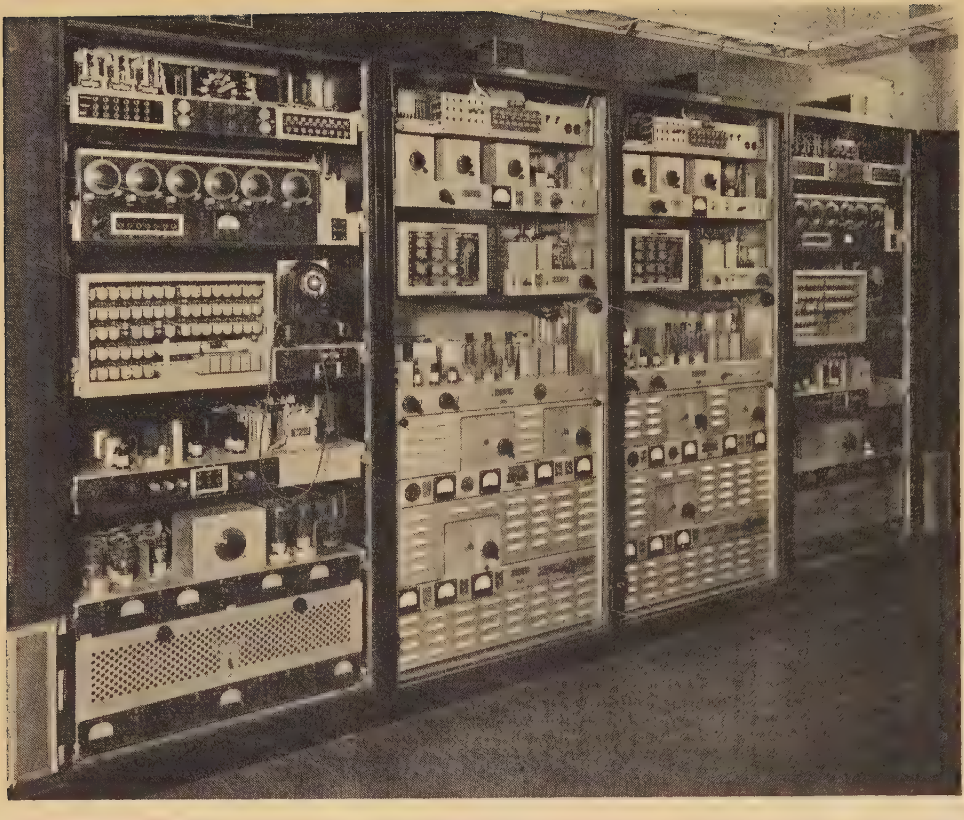


Figure 6. Four single-frequency power-line carrier-telephone sets

be required to set up a telephone connection. The telephone line serving the station operators or the system load dispatchers is arranged electrically to provide a feature called "preferred service," which permits an operator or dispatcher to have priority use of the carrier-telephone channel at all times, as contrasted to other telephone extension lines which receive a busy signal and are automatically locked out during all conversations not involving that particular telephone.

Before dialing on a party line, it is necessary to determine if the channel is in use. On nonpreferred telephone lines, this busy indication is given automatically. On preferred lines, it is necessary to monitor the channel to determine if it is being used. The call is placed by dialing a three-digit number. Within a few seconds after dialing has been completed, a distinctive tone is heard by the calling party, which indicates that the bell of the called telephone is ringing.

Two types of directories have been issued for the carrier-telephone system, namely, a directory printed on colored sheets, corresponding to channel designations, and a color-coded chart. The use of a directory helps to eliminate the dialing of wrong numbers and expedites interconnections of individual channels by furnishing the calling party with specific information for requesting the correct channel and desired number. For example, a station at one end of the system can communicate with a station at the other end of the system, a distance of 382 transmission-line miles, merely by requesting the system load dispatcher to connect the proper channels and dialing the desired number.

Power Supply. The power supply to all carrier-telephone sets installed by the Authority is secured normally from the 115-volt, a-c station service circuit. However, extreme variation or failure of normal power supply does not interrupt communication. An emergency source of a-c power is provided at each point, consisting of a motor alternator operated on the station control battery which is automatically controlled by a motor-starting and transfer panel. This emergency power is available so quickly that only a momentary interruption is noticeable while one is talking over the carrier-telephone channels during a change in the source of power supply. Upon restoration of the normal supply voltage to a value within the satisfactory operating limits of the carrier-telephone sets, the motor alternator is shut down, and the carrier-telephone bus automatically returns to the station service supply.

Emergency power equipment is available at all locations except one, where an early-model single-frequency duplex set is located. Power supply for this set is secured from the station storage battery and a four-unit motor alternator, the 115-volt station service supply not being required. At another point, a motor alternator for emergency power is used jointly by the a-c operated pilot-relay carrier sets and the telephone sets. At two of the hydroelectric generating stations, a motor alternator for emergency power supply is used jointly by the carrier-telephone sets and the load and frequency control equipment.

Cables and Line-Tuning Units. In contrast to all pilot-relay carrier sets being mounted out of doors in weather-

proof cabinets, the carrier-telephone sets are all mounted indoors. The location of the telephone sets varies from a minimum of 250 feet to a maximum of 1,500 feet from the line tuning units. To connect the telephone sets with the line tuning units, two general types of lead-in cable are used:

1. Parallel twin-conductor high-grade rubber-insulated cable covered with a lead sheath.

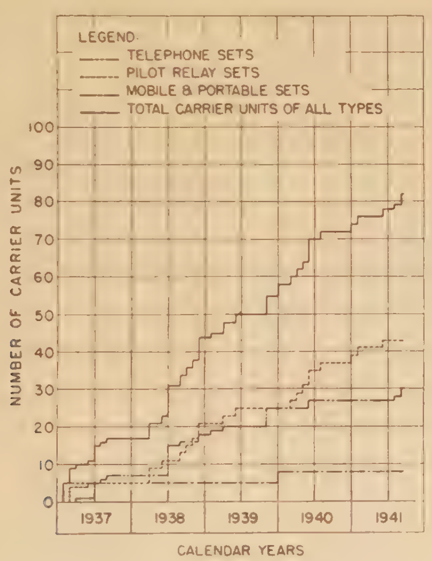
2. Concentric cable consisting of a stranded special rubber-insulated conductor around which is braided a copper shield covered with a lead sheath or a rubber jacket.

Concentric cable has been used in more recent projects, because its transmission efficiency is greater, and it is somewhat easier to handle during installation.

The lead-in cables are connected to impedance-matching transformers located in weatherproof boxes in the switchyards in order to minimize loss of carrier power at this point. The schematic circuit of a typical two-frequency telephone-line tuning unit is included in Figure 2. A two-frequency line-tuning unit is mounted on the right-hand side of the steel structure supporting the coupling capacitor assemblies in Figure 8, which shows the same principal items of equipment included in Figure 2.

In addition to impedance-matching transformers, the line-tuning unit contains the inductances and parallel resonant circuits necessary for tuning the two coupling capacitors to provide two interphase-coupled, single-frequency carrier channels, each operating on a separate and distinct frequency. The parallel resonant circuits, or trap circuits, are employed to prevent the flow of power, at the frequency to which they are tuned, into other directly connected circuits where it would be undesirable. Protective equipment, consisting of 60-cycle drainage coils, gaps, and grounding switches, shown in Figure 2, is included in the line-tuning unit to protect personnel and apparatus.

Figure 7. Progress chart showing growth of power-line carrier systems



A single-conductor cable with special rubber insulation is used between the line-tuning unit and each coupling capacitor. Since the voltage on this wire at carrier frequencies is relatively high, and since any variation in carrier-frequency leakage has more pronounced effects in this portion of the carrier circuit than in any other, it is necessary to avoid serious carrier signal-strength variations by minimizing leakage due to dirty insulators, sleet, and rain. The line-tuning units are, therefore, located as close to the coupling capacitors as feasible. In the Tennessee Valley Authority's system, this distance is generally less than ten feet. This conductor is supported on as few insulators as possible to reduce the number of parallel leakage paths to ground and with at least six-inch clearance between other parallel conductors and steel beams in order to keep the stray capacitance to earth as low as possible.

All carrier-telephone channels are coupled to the outside phase wires of the transmission lines with one exception in which a channel operates on the middle phase wire to ground. The carrier-communication frequencies are confined to the transmission line conductors proper by the use of line traps. At intermediate stations, the carrier-communication frequencies are by-passed around the switchyards, so that the switching of power circuits will not disturb the operation of telephone channels.

Portable and Mobile Equipment. The Tennessee Valley Authority has made considerable use of a portable carrier-telephone set which operates from a six-volt storage battery. This portable set weighs 141 pounds. The leg-type supports can be folded back against the sides of the weatherproof housing to provide handles for carrying. This set was used for nearly two years at a large temporary substation, and the savings in communication costs more than offset the original price of the set.

Two general types of carrier receivers have been installed in automobiles:

1. A single-frequency fixed-tuned receiver.

2. A variable-tuned receiver with one band covering a range of 50 to 150 kilocycles.

A variation of the second type of receiver has just been secured, which combines variable tuning in the power-line carrier range in two bands and provides a third band in the medium short-wave radio-frequency range of two to three megacycles for use with radio-telephone sets during emergencies. During normal times, the cars equipped with carrier receivers listen in for messages directed to them during two prearranged five-minute periods each hour. During emergencies, these automobiles leave their carrier receivers in operation continuously when within receiving distance of the channels. Receivers are equipped with noise-suppression circuits

which render the speakers silent when calls are not being received, thus eliminating noises which would otherwise be distracting.

Two-frequency portable carrier-line traps are used for grounding the transmission circuits. These traps weigh only one-tenth as much as standard two-frequency traps

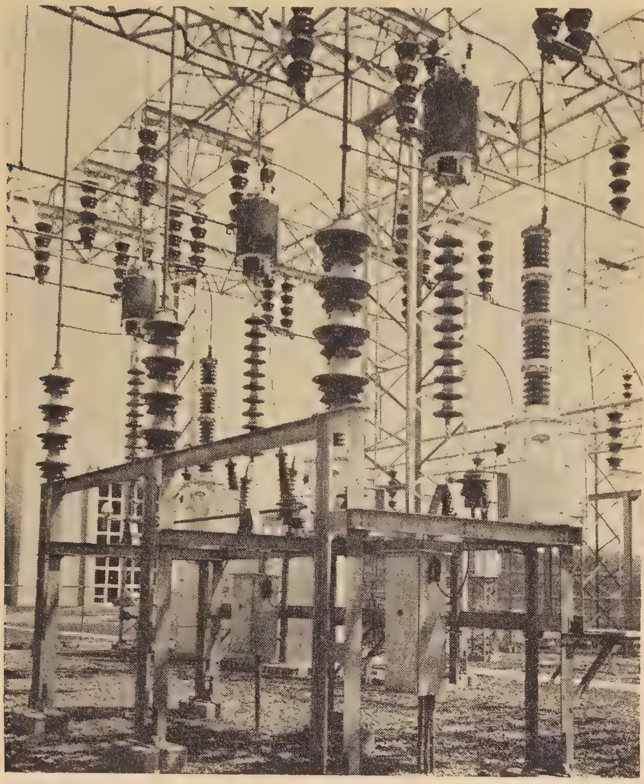


Figure 8. Carrier terminal equipment showing coupling capacitors and line traps for one relaying and two communication channels

and are designed to be connected in series with ground cables required to protect linemen when working on a de-energized power line. This arrangement prevents the short-circuiting of the carrier-telephone circuit and allows uninterrupted use of the channels during power-line repair periods.

Operating Experience. Operating experience with over 100 each of coupling-capacitor assemblies and carrier-line traps indicates that the maintenance of this type of apparatus is comparable to that required on similar high-voltage equipment in the switchyard. Since bird baffles have been added, and the tuning packs made weatherproof in the traps, only one case of trouble has been experienced, which was the result of a cracked porcelain bushing used to insulate one end of a trap through-bolt.

The over-all operation of the carrier telephone sets has been kept at a satisfactory level by following a program of inspection and tests at regular intervals. Checking the operating condition of carrier equipment is expedited by the use of a variety of standard electrical testing apparatus. The analysis of trouble reports, which is made at the completion of the correction of each case of trouble, has permitted modifications to be planned so that minor weak points have been eliminated. The manufacturers of the carrier equipment co-operated closely in working out jointly the carrier application problems, as well as assisting in setting up detailed maintenance instructions.

Even though the principal relay assemblies in all o the carrier-telephone sets are protected by dust covers, it is still necessary to keep the air-intake filters clean, as well as to remove dust from the equipment in dusty locations by means of a vacuum cleaner at periodic intervals. The individual shelves of the carrier-telephone assemblies are capable of being rolled forward from their cabinets and, in some cases, rotated upward and latched in an angle position, so that cleaning and inspection of the underside of the shelf is as convenient as checking the topside.

Conclusions. The conclusions from the preceding facts, as well as from an analysis of operating data, are that diversification of types and routings of communication circuits affords maximum communication dependability. In a power organization, where the utmost reliability is desired, this diversification should include the use of power-line carrier-telephone channels which have been carefully planned to realize fully the inherent reliability of carrier service.

The interconnection of individual single-frequency carrier-telephone channels is feasible and permits the extension of this type of service over a much greater area than would otherwise be possible.

Periodic analysis of telephone traffic over all communication circuits provides a basis for determining the most efficient distribution of traffic, and this results in leveling traffic peaks, thereby reducing delays in communication during these periods. Such traffic studies help to keep the loading equalized between individual circuits in order to secure the greatest return on the investment.

Performance records reveal that the general use of emergency power-supply equipment adds to the reliability of carrier-telephone service by providing power when station-service power supply has either failed or is otherwise abnormal.

The continuity of service rendered by carrier-telephone sets can be kept at a maximum by following a maintenance program which incorporates thorough inspections at regular intervals—planned to detect irregularities in advance of their developing into conditions interfering with operation, especially in the case of vacuum tubes. If routine checks are carefully made, the possibility of extended service interruptions is rather remote.

REFERENCE

1. Rating of Potential Devices and Suggested Material for a Standard. J. E. Clem, P. O. Langguth. AIEE Transactions, volume 58, 1940, December section, pages 676–80.

INSTITUTE ACTIVITIES

AIEE Officers to Be Nominated for 1943 Election

For the nomination of national officers to be voted upon in the spring of 1943, the AIEE national nominating committee will meet during the national technical meeting, New York, N. Y., January 25–29, 1943. The officers to be elected are: a president, a national treasurer, three directors, and five vice-presidents, one from each of the even-numbered geographical Districts. Fellows only are eligible for the office of president, and Members and Fellows for the offices of vice-president, director, and national treasurer.

To guide this committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for the consideration of the committee, all such suggestions must be received by the secretary of the committee at Institute headquarters, not later than December 15, 1942.

In accordance with the provisions in the constitution and bylaws, as amended during 1935 and quoted in the following paragraphs, actions relative to the organization of the national nominating committee are now under way.

Constitution

28. There shall be constituted each year a national nominating committee consisting of one representative of each geographical District, elected by its executive committee, and other members chosen by and from the board of directors not exceeding in number the number of geographical Districts; all to be selected when and as provided in the bylaws. The national secretary of the Institute shall be the secretary of the national nominating committee, without voting power.

29. The executive committee of each geographical District shall act as a nominating committee of the candidate for election as vice-president of that District, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

30. The national nominating committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The national nominating committee shall name on or before January 31 of each year, one or more candidates for president, national treasurer, and the proper number of directors, and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical Districts, if received by the national nominating committee when and as provided in the bylaws; otherwise the national nominating committee shall nominate one or more candidates for vice-president(s) from the District(s) concerned.

Bylaws

Sec. 22. During September of each year, the secretary of the national nominating committee shall notify the chairman of the executive committee of each geographical District that by December 15 of that year the executive committee of each district must select a member of that District to serve as a member of the national nominating committee and shall, by December 15, notify the secretary of the national nominating committee of the name of the member selected.

During September of each year, the secretary of the national nominating committee shall notify the chairman of the executive committee of each geographical district in which there is or will be during the year a vacancy in the office of vice-president, that by December 15 of that year a nomination for a vice-president from that District, made by the District executive committee, must be in the hands of the secretary of the national nominating committee.

Between October 1 and December 15 of each year, the board of directors shall choose 5 of its members to serve on the national nominating committee and shall notify the secretary of that committee of the names so selected, and shall also notify the 5 members selected.

The secretary of the national nominating committee shall give the 15 members so selected not less than 10 days' notice of the first meeting of the committee, which shall be held not later than January 31. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. All suggestions to be considered by the national nominating committee must be received by the secretary of the committee by December 15. The nominations as made by the national nominating committee shall be published in the March issue of *Electrical Engineering* (Journal of AIEE), or otherwise mailed to the Institute membership not later than the first week in March.

INDEPENDENT NOMINATIONS

Independent nominations may be made in accordance with provisions in article VI, section 31, of the constitution and section 23 of the bylaws, which are quoted below:

Constitution

31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the national secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be designed only by members within the District concerned.

Bylaws

Sec. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 31 (constitution), must be received by the secretary of the national nominating committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the national nominating committee in accordance with article VI of the constitution and sent by the national secretary to all qualified voters during the first week in April of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) H. H. Henline,
National Secretary

November 1, 1942

Plans Under Consideration for National Technical Meeting

An AIEE national technical meeting will be held in New York, N. Y., January 25–29, 1943, with headquarters in the Engineering Societies' Building. In accordance with the wartime policies of the Institute as adopted by the board of directors (*EE, Sept. '42, p. 477*) arrangements are being made for a number of technical sessions and conferences which will aid the war effort. Several sessions will deal with the conservation of copper and other critical materials both in the central-station and industrial-distribution fields. In co-operation with the AIEE standards committee and as already announced (*EE, Oct. '42, p. 527*), "guides" or "general principles" for the selection and operation of electric equipment are in preparation by several of the technical committees. These guides will serve as a basis for discussion in the sessions and conferences. Other sessions and conferences will deal with the subjects of dim-outs and their desirability, substitute materials—plastics and mica—and substitute materials for instruments.

For the general session consideration is being given to a program of speakers on the important subject of technical man power as an aid to the war effort. It is expected that both the military and industrial phases of this subject will be presented.

AIEE President H. S. Osborne (F '21) has appointed the following members on the general committee to make plans for the national technical meeting: *chairman*, C. R. Jones (M '30); F. A. Cowan (M '29); W. S. Hill (M '30); M. D. Hooven (M '30); A. E. Knowlton (F '30); R. L. Webb (M '35); C. C. Whipple (M '26); C. S. Purnell (M '35).

IEE Offers Facilities to US Electrical Engineers in Britain

The Institution of Electrical Engineers, London, England, in an effort to be of service to members of technical units of allied military forces in Great Britain has announced that its professional facilities, already at the disposal of Canadian and Polish engineers, are being made available to electrical engineers in the United States Army stationed in England. Although in the past there has been a mutual exchange of membership privileges between the IEE and the American Institute of Electrical Engineers, the IEE is now extending its hospitality to all members of the electrical engineering profession serving in the United States Army in Britain, according to an invitation issued by President N. Ashbridge of the IEE to General Dwight D. Eisen-

Future AIEE Meetings

National Technical Meeting
New York, N. Y., January 25–29, 1943

District Technical Meeting
Providence, R. I., April 7–9, 1943

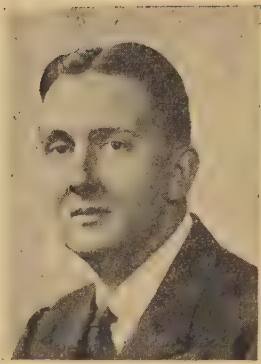
District Technical Meeting
Kansas City, Mo., April 28–30, 1943

National Technical Meeting
Cleveland, Ohio, June 21–25, 1943

hower, commanding general of the United States Army in Great Britain. Through this invitation, use of the Institution's reference library and attendance at evening meetings will be possible for electrical engineers who wish to maintain some contact with their profession during their stay in England.

PERSONAL ....

W. R. Whitney



F. A. Lewis

C. A. Powel

Willis Rodney Whitney (A'01) vice-president in general charge of research, General Electric Company, Schenectady, N. Y., has been awarded the John Fritz Medal for 1943 (*p. 582, this issue*). Doctor Whitney was born in Jamestown, N. Y., on August 22, 1868. He was graduated from Massachusetts Institute of Technology with the degree of bachelor of science (1890), and from the University of Leipzig with the degree of doctor of philosophy (1896). He has also received the honorary degrees of doctor of science from Union College (1919) Syracuse University (1925), University of Michigan (1927), University of Rochester (1932); doctor of chemistry, University of Pittsburgh (1919); and doctor of laws, Lehigh University (1929). Since his graduation from Massachusetts Institute of Technology he has held the following positions at that institution: assistant instructor, general chemistry (1890–92), analytical chemistry (1892–94), sanitary chemistry (1896–98); instructor, theoretical chemistry and proximate analysis (1898–1901); assistant professor, theoretical chemistry (1901–04); nonresident associate professor, theoretical chemistry (1904–08); and nonresident professor of chemical research since 1908. In 1900 when the research laboratories of General Electric Company were established at Schenectady, N. Y., Doctor Whitney was appointed director of research. He became vice-president of the company and director of research in 1928, and upon his retirement in 1932 he was appointed vice-president in general charge of research. The Willard Gibbs Medal was bestowed upon Doctor Whitney in 1916, the Chandler Medal in 1920, the Perkin Medal in 1921, the gold medal of the National Institute of Social Sciences in 1928, and the Franklin Medal in 1931. He was awarded the AIEE Edison Medal in 1935, the distinguished service gold key of the American College of Physical Therapy in 1935, and the Marcellus Hartley Award of the National Academy of Sciences in 1938, and was named Chevalier of the Legion of Honor in 1937. Doctor Whitney is also a member of the American Chemical Society (president, 1909), American Society of Chemical Engineers, American Electrochemical Society (president, 1912), American Institute of Mining and Metallurgical Engineers, American Physical Society, American Association for the Advancement of Science, American Philosophical Society, American Academy of Arts and Sciences, National Academy of Sciences, and the National Research Council. He is also the author of a number of technical papers.

F. A. Lewis (A '31, M '35) associate editor of *Electrical Engineering* since 1936, has been designated to serve as acting editor for the duration of the editor's wartime leave of absence (*EE, Oct. '42, p. 528*). Born in Carverton, Luzerne County, Pa., on January 20, 1903, he was graduated from Syracuse University in 1926 with the degree of electrical engineer. His professional career includes engineering service in electric power, communications, and education. Mr. Lewis began his career in electrical engineering when, as a senior student in the summer of 1925 he was engaged in transmission and substation maintenance work for the Pennsylvania Power and Light Company, Wilkes-Barre. In 1926 he became associated with the New York (N. Y.) Edison Company, first serving in the test department (1926–29); during this period he was in responsible charge of special laboratory and field investigations pertaining to electrolysis problems, special distribution-system surveys and studies, and investigations of radio interference including the development of related special equipment. He also participated in the experimental development of carrier-current control devices for certain power-system equipment. In the transmission and distribution department (1929–30) he was engaged in the investigation of duct overheating and cable failure caused by the proximity or leakage of underground steam mains. Mr. Lewis was engaged in communications work during 1930–31 as a member of the technical staff of the Bell Telephone Laboratories, Inc., New York, N. Y. There he was engaged in ferromagnetic research, particularly with respect to the determination of the magnetic properties and behavior of certain special alloys under different conditions and as affected by various heat treatments. Some of this work involved the development of special methods of obtaining the required data. Mr. Lewis's activities in the field of technical education began while he was an undergraduate. While a junior and senior student he served as instructor in mechanical drawing at Syracuse University. From 1928 to 1931 he taught industrial mathematics in the evening school at Pratt Institute, Brooklyn, N. Y. Mr. Lewis joined the AIEE editorial staff in 1931 as assistant editor. He is also a member of Tau Beta Pi and Pi Mu Epsilon.

C. A. Powel (M '20, F '41) manager, headquarters engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been elected vice-president of the American Institute of Electrical Engineers, representing the Middle Eastern District (2). He will fill the unexpired term of Professor N. S. Hibshman (A '27, F '41), who resigned because of a change in district address. Mr. Powel was born in Rouen, France, on July 30, 1884, and was graduated from the Institute of Technology of Canton, Bern. From 1905 to 1911 he was associated with Brown, Boveri and Company, Baden, Switzerland, in the application engineering department, and in the latter year was sent to Japan as the company's resident technical engineer. He returned to England in 1915 to join the civil branch of the ordnance department and from 1916 to 1918 was engaged in ordnance work in the United States representing the British War Office. In 1919 he joined the central-station engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. He became manager, central-station engineering department, in 1935; manager, industry engineering department, in 1938; and was appointed to his present position in 1940. He became a naturalized citizen of the United States in 1930. He is a past director (1936–40) of the Institute. He was also a member of the AIEE Lamme Medal committee (1939–42), and the committees on power generation (1933–38), applications to marine work (1936–40), electric welding (1937–41), and electrochemistry and electrometallurgy (1939–40). He has served on the standards committee since 1939, the Charles LeGeyt Fortescue Fellowship committee since 1939 (chairman, 1939–41), and the committee on constitution and by-laws since 1940. He is currently serving on the committee on education. He is also a member of The American Society of Mechanical Engineers and an associate member of the Institute of Electrical Engineers, England.

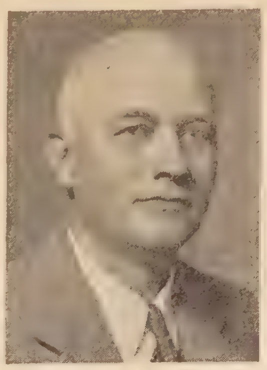
Gerard Swope (A '99, F '22) honorary president, General Electric Company, New York, N. Y., has been awarded the sixth Hoover Gold Medal. Details of the award are given on page 582 in this

issue. He was born on December 1, 1872, at St. Louis, Mo., received the degree of bachelor of science in electrical engineering from Massachusetts Institute of Technology in 1895, and has received the honorary degrees of doctor of science from Rutgers University (1923), Union College (1924), Washington University (1932); doctor of laws, Colgate University (1927); and doctor of engineering, Stevens Institute of Technology (1929). His first engineering experience was as a helper at General Electric Company, Chicago, Ill., in 1893. In 1895 he was employed by Western Electric Company, Chicago, Ill., as a design engineer, becoming manager of the St. Louis, Mo., office in 1899. In 1906 he returned to Chicago as general manager of power apparatus engineering department, and in 1908 he went to New York, N. Y., as general sales manager, becoming vice-president and director of the company in 1913. During World War I he was a member of the general staff of the United States Army. In 1919 he was made president of International General Electric Company, New York, N. Y., and was in charge of the companies abroad engaged in manufacturing, engineering, and commercial activities. He became president of the General Electric Company in 1922, and since 1927 has been chairman of the board of International General Electric. He was decorated by the Emperor of Japan with the Order of the Rising Sun (1917), was named Chevalier of the Legion of Honor by the French Government, and was awarded the United States Army Distinguished Service Medal, and the gold medal of the National Institute of Social Sciences (1932). He has been a member and chairman of various national and foreign technical and public service committees, including the AIEE committee on the Iwadare Foundation (1931–35). He is also an honorary member of Tau Beta Pi. He is the author of various technical papers and articles and the holder of several patents.

S. P. MacFadden (A '19, M '30) vice-president in charge of operations, Puget Sound Power and Light Company, Seattle, Wash., has been elected executive vice-president. He has been with the company since 1930. He was born June 17, 1894, in Laredo, Tex., and received the degree of bachelor of science in electrical engineering from Texas Agricultural and Mechanical College in 1916. In that year he joined Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., as a student engineer, and in 1917 he entered the distribution department, Eastern Texas Electric Company, Beaumont. After serving in the United States Army, he returned to Eastern Texas Electric Company in 1919, serving successively as assistant manager until 1925 in the Beaumont and Port Arthur, Tex., offices, and as assistant to the manager of the Southwestern district of Stone and Webster, Inc., Houston, Tex. From 1925 to 1929 he served first as manager and later vice-president of Western Public Service Company, and Missouri Service Company, Scottsbluff, Neb., and its predecessors. In 1930, after a short period with Stone and Webster Service Corporation, Boston, Mass., he was appointed vice-president, Puget Sound Power and Light Company. **C. P. Terrell** (A '10, M '18) operating manager, has been appointed vice-president of the company. Born May 1, 1885, at Jerseyville, Ill., he was graduated from University of Washington in 1910 with the degree of bachelor of science in electrical engineering. He was first employed by the Seattle (Wash.) Electric Company, one of the predecessors of Puget Sound Power and Light Company, in 1903, advancing from substation operator to superintendent of light and power of the latter's northwestern division, Bellingham, Wash., in 1922. In 1924 he left the company to become successively an executive for El Paso (Tex.) Electric Company, Tampa (Fla.) Electric Company, and Gulf States Utilities Company, Beaumont, Tex. He returned to the Puget Sound Power and Light Company in 1940 as operating manager in charge of the central-station division and the system's generation, transmission, and distribution.

J. H. Lampe (A '20, M '26) dean of engineering, professor of electrical engineering, and head of the electrical-engineering department, University of Connecticut, Storrs, has been appointed chairman of the AIEE technical committee on electric welding for 1942–43. He has served on that committee since 1939. He was born December 1, 1896, in Baltimore, Md., and was graduated from Johns Hopkins University with the degrees of bachelor of science in engineering (1918), master of electrical engineering (1925), and doctor of electrical engineering (1931). From 1918 to 1919 he served with the United States Army, and then entered the laboratory division of Winchester Repeating Arms Company, New Haven, Conn., as research engineer. In 1920 he returned to Johns Hopkins University, first as instructor in electrical engineering, then assistant professor, and finally, associate professor. In 1938 he went to the University of Connecticut as professor and head of the electrical engineering department, and in 1940 was made dean of the school of engineering. He has served in various capacities for short periods with Consolidated Gas Electric Light and Power Company, Baltimore, Md.; Chesapeake and Potomac Telephone Company, Washington, D. C.; Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.; and General Electric Company, Schenectady, N. Y. He was secretary of the AIEE Baltimore Section (1933–37), and a member of the membership committee (1933–34). He is currently serving on the technical program committee, and is a member of the executive committee of the Connecticut Section. He is also a member of the American Society for Testing Materials, the Society for the Promotion of Engineering Education, Tau Beta Pi, and Sigma Xi, and is the author of several technical articles.

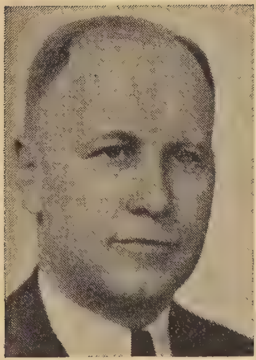
F. F. Ambuhl (A '17, M '26) assistant to the chief engineer, Toronto (Ont.) Hydro-Electric System, has been appointed chairman of the AIEE technical committee on automatic stations for 1942–43. He has served on that committee continuously since 1930. He was born January 25, 1886, in Farina, Ill., and received his early engineering experience with Ford, Bacon and Davis, Engineers, Birmingham, Ala., in electrical construction work. In 1908 he entered the employ of Westinghouse Electric and Manufacturing Company, Langdale, Ala., where he was engaged in the installation and operation of a five-unit hydroelectric plant. During 1910–11 he was associated briefly with the Macon (Ga.) Railway and Light Company as superintendent of construction, and with J. C. White Corporation, Atlanta, Ga., in overhead rehabilitation construction. From 1911 to 1912 he was again affiliated with Westinghouse company as erecting engineer, first near Atlanta, Ga., and later in Charlotte, N. C. In 1912 he left that company to become resident electrical engineer for Big Dome Gold Mines, Ontario, where he served until 1913. From 1913 to 1917 he was assistant engineer of stations, Toronto (Ont.) Hydro-Electric System, and from 1917–19 was general manager and chief engineer, National Abrasive Company, Hamilton and Niagara Falls, Ont. When the plant closed shortly after the end of the World War I he rejoined the Toronto Hydro-Electric System, and he has served since 1920 in his present position. He is a past chairman of the Toronto



J. H. Lampe

Gerard Swope

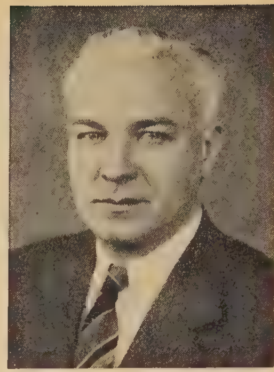
F. F. Ambuhl



R. G. Warner

A. G. Oehler

F. E. Harrell



J. H. Pilkington

Section (1929–30), and is currently a member of the technical program and standards committees.

J. H. Pilkington (A '26, M '34) division engineer, system engineering department, Consolidated Edison Company of New York, Inc., has been appointed chairman of the AIEE membership committee for 1942–43. He has served on that committee since 1939. He was born February 20, 1898, in Highmore, S. D., and received the degree of bachelor of science in electrical engineering in 1922 from the University of Michigan. He immediately entered the design school course of Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and in 1923 was transferred to the power section of the transformer engineering department. Later in the year he joined Brooklyn (N. Y.) Edison Company, Inc., as technical assistant to the outside plant engineer, and, except for a short period during 1924 when he was employed as sales engineer for Pittsburgh Transformer Company, New York, N. Y., he has been associated since with the Consolidated Edison System. From 1924 to 1936 he was with Brooklyn Edison company, serving successively as technical assistant to the outside plant engineer; assistant engineer, outside plant bureau of the electrical-engineering department; assistant supervisor, cable bureau of the purchasing department; department assistant, purchasing department; and division engineer, commercial engineering bureau of the sales department. In 1936 he was transferred to Consolidated Edison company, where he served first as manager of the technical bureau, and more recently, as division engineer, system engineering department. He is an associate member of Sigma Xi and a member of Tau Beta Pi.

A. G. Oehler (A '18, F '26) editor, *Railway Electrical Engineer;* electrical editor, *Railway Age;* Simmons-Boardman Publishing Corporation, New York, N. Y., has been appointed chairman of the AIEE technical committee on land transportation for 1942–43. He has been a member of this committee since 1941. Born November 12, 1888, at Lake Mills, Wis., he received the degree of bachelor of science in electrical engineering (1911) from the University of Wisconsin. From 1911 to 1913 he was employed in the testing department of General Electric Company, Schenectady, N. Y., and from 1913 to 1915 he was associated with Northern Pacific Railway Company, St. Paul, Minn., in electrical construction work. In 1915 he was appointed general foreman electrician for Wisconsin Minnesota Light and Power Company, Eau Claire, Wis., and in 1917 he resigned to become associate editor of *Railway Age* and *Railway Electrical Engineer.* He has been with the Simmons-Boardman company since 1917, with the exception of a brief period during 1918–19 when he was on leave as ensign in the United States Naval Reserve. He became managing editor of *Railway Electrical Engineer* (1918), associate editor of *Railway Age* (1919), and was appointed to his present position in 1920. Mr. Oehler is a past president of the American Welding Society. He was chairman of the AIEE New York Section (1936–37) and a member of the board of examiners (1937–42). He has served on the publication committee since 1937, and is currently a member of the standards and technical program committees.

R. G. Warner (A '19, M '20) engineering department, United Illuminating Company, New Haven, Conn., has been appointed chairman of the AIEE national committee on Student Branches for 1942–43. He has served on that committee since 1940. Born November 18, 1892, at New Haven, Conn., he received the degrees of bachelor of philosophy (1914) and electrical engineer (1920) from Yale University. From 1914 to 1916 he was with Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., in the student course and later as switchboard engineer. He became instructor in the department of electrical engineering at Yale University, New Haven, Conn., in 1916, and continued in that department as instructor and assistant professor until 1939, when he was appointed engineer in charge of special work for the United Illuminating Company, New Haven, Conn. In addition to his affiliation with that company he was also electrical engineer for the Connecticut Public Utilities Commission (1930–39), and has been consulting engineer for various companies. He was chairman of the AIEE Connecticut Section (1931–32), and served on the education (1924–25) and standards (1937–39) committees, and the committee on electrical machinery (1931–33). He is currently serving as a director of the Institute, and is a member of the executive committee and the committee on domestic and commercial applications. He is also a member of the Society for the Promotion of Engineering Education, Tau Beta Pi, and Sigma Xi.

F. E. Harrell (A '26, F '40) assistant chief engineer, Reliance Electric and Engineering Company, Cleveland, Ohio, has been appointed chairman of the AIEE committee on electrical machinery for 1942–43. He has served as a member of this committee since 1936. Born October 29, 1903, in Logansport, Ind., he was graduated from Purdue University with the degrees of bachelor of science in electrical engineering (1924) and electrical engineer (1929). Following a short period in the student course of Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., he joined the Reliance Electric and Engineering Company in 1924 as sales engineer in the Chicago, Ill., office. In 1927 he was transferred as design engineer to the Cleveland office, where he has worked continuously since that date. He was appointed successively engineer in charge of mechanical design (1929), engineer in charge of a-c design (1932), and assistant chief engineer (1934). He was chairman of the Cleveland Section (1937–38), and a member of the committee on applications to iron and steel production (1934–38). He has also served on the committee on industrial power applications since 1938, and is currently serving on the standards and technical program committees. He is a civil member of the American Society of Naval Engineers.

Louis Casper (M '23) recently retired general inspector, general traffic department, Western Union Telegraph Company, New York, N. Y., has become patent counsel for a number of corporations. He is associated with Leo Mandelstam, New York, N. Y. He was born June 15, 1871, in Manchester,

England, and has served the Western Union company at various times and in various capacities since 1886, when he first joined the company in the automatic repair shop, New York, N. Y. Following his apprenticeship there (1886–90) and early work as repeater and wire chief, Cheyenne, Wyo. (1890–93), he spent three years specializing in small isolated and municipal electric power plants before returning in 1896 to Western Union. During this period of association (1896–1906) he patented a printing telegraph system and several electrical devices. From 1906 to 1908 he was employed by the Sandwich Electric Company, first in the laboratory development of composite telephone and telegraph equipment and later as contracting engineer. Another year with Western Union in automatic telegraph work and as instrument and cable inspector preceded his appointment in 1909 as principal, department of telephone and telegraph engineering, Port Arthur (Tex.) Collegiate Institute. From 1911 to 1914 he was superintendent of equipment, Gulf division, Western Union Telegraph Company, Dallas, Tex., and in the latter year was appointed general inspector in New York, N. Y.

M. F. Skinker (A '22, F '34) formerly associate director of research, technical development and research department, Consolidated Edison Company of New York, Inc., has recently been appointed chief development engineer, selenium rectifier division, International Telephone and Radio Manufacturing Company, East Newark, N. J. He had been affiliated with the Consolidated Edison System since 1924, when he joined Brooklyn (N. Y.) Edison Company, Inc., as assistant research engineer in the electrical engineering department. He became assistant director of research in 1926, and in 1937 was transferred to Consolidated Edison Company of New York, Inc., in the same capacity. He remained in that position until his recent withdrawal from the company. He was born April 12, 1898, in Denver, Colo., and received the degrees of bachelor of science in electrical engineering (1919) and master of science in electrical physics (1921) from the University of Colorado, and doctor of philosophy in electrical physics (1924) from Oxford University, England. He was a member of the AIEE technical program committee (1938–40), and has served on the committee on electrochemistry and electrometallurgy since 1936 (chairman 1938–40), and the committee on basic sciences since 1942. He is also a member of the American Society for Testing Materials and the American Physical Society.

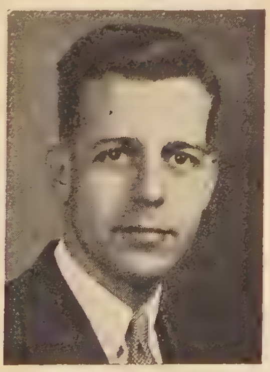
A. C. Monteith (A '25, M '40) manager, industry engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been appointed chairman of the AIEE technical committee on power generation for 1942 to 1943. He has served as a member of that committee since 1938. He was born April 10, 1902, in Brucefield, Ont., and received the degree of bachelor of science in 1923 from Queens University, Kingston, Ont. While still an undergraduate in 1922, he entered the student course, Canadian Westinghouse Company, Hamilton, Ont., and from 1923 to 1924 he was associated with Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., as engineer in the graduate student course. He has been with the Westinghouse company continuously since 1923. He became central station engineer in 1924, manager, central-station engineering department in 1938, and in 1941 was appointed to his present position. He was a member of the AIEE committee on protective devices (1940–42), and has served on the standards committee since 1941. He is currently serving on the technical program committee.

T. B. Holliday (A '41) major, United States Army Air Corps, Wright Field, Dayton, Ohio, has been appointed chairman of the AIEE technical committee on air transportation for 1942–43. He has served on that committee since 1941. Born June 18, 1906, in Frankfort, Ind., he was graduated from Purdue University with the degrees of bachelor of science in electrical engineering (1927), master of science in electrical engineering (1929), and electrical engineer (1931). From 1927 to 1929 he was assistant instructor in physics at Purdue University, Lafayette, Ind., and in 1929 he entered the engineering employ at Wright Field as a junior electrical engineer in design and testing of aircraft lighting. In 1933 he was engaged in a study of methods to reduce radio interference and later supervised the development of a-c power supply and equipment for use in aircraft. He became assistant electrical engineer in 1936, and associate engineer in 1940. He is currently serving on the AIEE technical program and standards committees.

C. V. Aggers (A '39) manager, engineering and manufacturing, Westinghouse X-Ray Company, Inc., Long Island City, N. Y., has been appointed chairman of the AIEE committee on the applications of electricity to therapeutics for 1942–43. He has served as a member of this committee since 1941. He was born September 3, 1905, in Franklin, Pa., and in 1925 entered the radio engineering department of Westinghouse Electric and Manufacturing Company, Baltimore, Md. From 1928 to 1931 he attended Westinghouse technical night school, and in 1932 was placed in charge of radio-interference problems for the entire company. Prior to his appointment as manager of engineering and manufacturing, he was connected with the engineering laboratories and standards department, East Pittsburgh, Pa. He is currently serving on the AIEE standards and technical program committees.

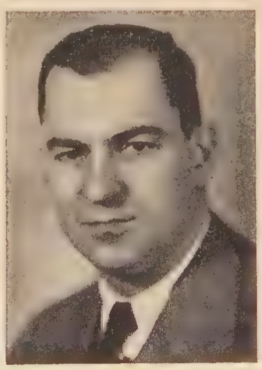
W. F. Ogden, Jr. (M '41) commercial engineer, Edison General Electric Appliance Company, Inc., Chicago, Ill., has been appointed chairman of the AIEE technical committee on domestic and commercial applications for 1942–43. He was born October 20, 1904, in New Orleans, La., and received the degrees of bachelor of arts (1926) and electrical engineer (1941) from Swarthmore College. In 1926 he entered the test course of General Electric Company, Schenectady, N. Y., and in 1927 was transferred to the central station engineering department. In 1928 he became associated with Georgia Power Company, serving successively in the purchasing department (1928–29), as substation engineer in the operating department (1929–30), and as general superintendent of appliance repairs (1930–36). In 1937 he joined Edison General Electric Appli-

C. V. Aggers



W. F. Ogden, Jr.

T. B. Holliday



A. C. Monteith

ance Company as commercial engineer. He is currently serving on the AIEE technical program and standards committees.

E. W. Schilling (A '29, M '33) professor and head of the department of electrical engineering, Montana State College, Bozeman, has been appointed acting dean of engineering. He joined the teaching staff of Montana State College in 1938 as professor and head of the department. He received the degree of bachelor of science in electrical engineering (1919) from the University of Illinois, and the degrees of master of science in electrical engineering (1930), doctor of philosophy (1933), and electrical engineer (1936) from Iowa State College.

F. C. Todd (A'27) formerly assistant professor of electrical engineering, mineral industries experiment station, Pennsylvania State College, State College, Pa., has joined the technical staff of Battelle Memorial Institute, Columbus, Ohio, where he has been assigned to research in industrial physics. He was graduated from Oklahoma Agricultural and Mechanical College in 1925 with the degree of bachelor of science, and holds graduate degrees from Carnegie Institute of Technology and the University of Chicago (*See EE, Sept., '42, p. 480*).

H. A. Walsh (A '30, M '31) electrical engineer, Doble Engineering Company, Medford Hillside, Mass., still remains in that position. He is not the new business manager of the El Paso (Tex.) Electric Company as was stated in the October 1942 issue of *Electrical Engineering*, page 532. The H. A. Walsh who was appointed to that position is a nonmember of the Institute.

OBITUARY • • • •

H. Clyde Snook (A '05, F '20) consulting engineer, Summit, N. J., died September 23, 1942. He was born March 25, 1878, in Antwerp, Ohio, and received the degrees of bachelor of arts (1900) from Ohio Wesleyan University, master of arts (1902) from Allegheny College, and master of science (1910) from Ohio Wesleyan University. During 1900–01 he taught physics and chemistry in the high school, Soldiers' and Sailors' Orphans Home, Xenia, Ohio, and during 1901–02 he was assistant professor of chemistry, Allegheny College, Meadville, Pa. After a brief association with Queen and Company, Philadelphia, Pa. (1902–03), as salesman and electrical expert, he became president of the Roentgen Manufacturing Company, Philadelphia, Pa., and was in charge of technical development and manufacturing. He served in this capacity until 1913, when he became president of that company's successor, the Snook-Roentgen Manufacturing Company. From 1916 to 1917 he was vice-president of the Victor Electric Corporation, Chicago, Ill., and in the latter year he became electrical engineer with Western Electric Company, New York, N. Y. From 1925 to 1927 he served with the Bell Telephone Laboratories, and since 1927 had been a consulting engineer. He was a past chairman (1911–12) of the Philadelphia Section, held several United States and foreign patents, and was the author of various technical articles and papers. He was honored three times for his experimental work; having received the Edward Longstreth medal of the Franklin Institute, the gold medal of the Radiological Society of North America, and the gold medal of the American College of Radiology.

James Preston Edwards (A '92, M '13) retired traffic superintendent, eastern division, Western Union Telegraph Company, New York, N. Y., died July 10, 1942. He was born July 31, 1868, in Saluda County, S. C., and was graduated from Richmond Military Academy, Atlanta, Ga., in 1880. His early engineering work consisted of shop experience, installation of isolated industrial lighting plants, power surveys, and erection of telegraph power plants and wiring. From 1893 to 1896 he was associated with National Electric Manufacturing Company, Eau Claire, Wis., in power and lighting work. From 1896 to 1910 he was telegraph engineer in southern territory for Postal Telegraph Company, becoming division electrical engineer in 1905. In 1910 he joined the engineering staff of Western Union Telegraph Company, New York, N. Y., in the office of the engineer of equipment, and during 1911–12 he was traffic superintendent of the southern division, Atlanta, Ga. In 1914 he was appointed to a similar position in the metropolitan district, and in 1916 he was transferred as traffic superintendent of the western division, Chicago, Ill. In 1919 he was appointed to the staff of the vice-president in charge of traffic, New York, N. Y., and in 1921 he was appointed traffic superintendent to the eastern division, a position he held until his retirement in 1932.

John Elliott Brown (A '03) retired general manager, Ottawa Hydro-Electric Commission, died August 23, 1942. Born April 19, 1869, in Charlottetown, Prince Edward Island, he was engaged in the electrical engineering profession for 50 years. Following a short period in the testing department of the Prince Edward Island Electric Company in 1887, he joined the Royal Electric Company, Montreal, Que., in the testing and electrical construction division. In 1890 he became associated with Thompson Houston Electric Company, Lynn, Mass., and later in the year returned to Charlottetown to install an a-c plant for the Prince Edward Island Electric Company. In that same year he became electrical engineer for Standard Electric Company, Ltd., Ottawa, Ont. During his association with this company (1890–95) he designed and laid out their complete electrical works. From 1895–96 he worked for the Deschene (Que.) Electric Company, installing an a-c plant, and in 1896 he was appointed electrical engineer in charge of design and construction work. He remained with the company until 1901, ultimately becoming superintendent, and in 1901 he transferred to Consumers Electric Company, Ottawa, Ont. He continued with that company and its successor, the Ottawa Hydro-Electric Commission, until his retirement in 1937.

Edward Louis Glander (A '11) maintenance engineer, Southwestern Bell Telephone Company, Dallas, Tex., died September 10, 1942. He was born March 21, 1881, in Milwaukee, Wis., and first entered the electrical field in 1900 in the employ of Northwestern Telephone Company, St. Paul, Minn. From 1900 to 1906 he served in the installing department of that company, and from 1907 to 1908 he was superintendent, Chippewa Valley Telephone Company, Bruce, Wis. In 1909 he became associated with the Northern Pacific Railway Company, St. Paul and Staples, Minn., and later in the year was engaged in general telegraph work at Mandan, N. D. From 1910 to 1915 he was associated, first, with the Dakota Central Telephone Company, Aberdeen, and later, the Automatic Electric Company, Chicago, Ill. From 1915 to 1919 he worked for the Interstate Commerce Commission, Kansas City, Mo., and in 1919 he joined the engineering department, Southwestern Bell Telephone Company. He remained with the company continuously until his death, serving from 1921 to 1926 in the St. Louis (Mo.) office. He was also a member of the Telephone Pioneers of America.

Charles S. Zimmer (A '37) southwestern district manager, Bussman Manufacturing Company, Houston, Tex., died July 21, 1942. He was born May 22, 1891, in New Orleans, La. He entered the electrical field in 1907 as lineman and meter repairer, installer, and tester, for the New Orleans (La.) Railway and Light Company. In 1916 he became power salesman for Birmingham (Ala.) Railway Light and Power Company, and in 1916 he became high lineman with Alabama Power Company, Birmingham. After various associations with Economy Fuse and Manufacturing Company and the Fairbanks Company, New Orleans, La., he entered the employ of Bussman Manufacturing Company, St. Louis, Mo. With the exception of a three-and-one-half year association with Fairbanks Morse and Company, New Orleans, La., he had worked continuously for the Bussman company in St. Louis, Mo., and Houston, Tex., first as salesman, and finally as southwestern district manager.

Richard Lee Herpich (A '42) second lieutenant, Signal Corps Reserve of the United States Army, 425 Signal Company Aviation, Hamilton Field, Calif., died July 30, 1942. Born Sept. 12, 1920, in Pittsburgh, Pa., he was graduated from

Carnegie Institute of Technology in 1941 with the degree of bachelor of science in electrical engineering. He entered the employ of Union Switch and Signal Company, Swissvale, Pa., as student engineer in 1941. In March he left that company to accept a commission in the United States Army. He was also a member of Eta Kappa Nu.

MEMBERSHIP . .

Recommended For Transfer

The board of examiners, at its meeting on October 15, 1942, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Diederich, Peter, superintendent, public service department, City of Glendale, Calif.
Feiker, F. M., dean, school of engineering, The George Washington University, Washington, D. C.
Halpenny, R. H., chief engineer, California Electric Power Company, Riverside, Calif.
Henninger, G. Ross, editor, AIEE, New York, N. Y. (now on leave, serving as lieutenant colonel, Army Specialist Corps, Washington, D. C.).
Rollow, J. G., supervising engineer, Southern Calif. Gas Company, Los Angeles, Calif.

5 to grade of Fellow

To Grade of Member

Carpenter, W. P., engineer, Superior Electric Company, Bristol, Conn.
Collins, H. W., assistant to superintendent of electrical system, Detroit Edison Company, Detroit, Mich.
Fifer, Wm. H., senior electrical engineer, Bureau of Ships, Navy Department, Washington, D. C.
Flutsch, Leo, electrical design engineer, Braden Copper Company, Rancagua, Chile, S. A.
Foulon, Fred, electrical research and development engineer, Douglas Aircraft Company, Santa Monica, Calif.
Grier, L. N., electrical engineer, Aluminum Company of America, Pittsburgh, Pa.
McCoin, B. H., superintendent, Bureau Power, Knoxville Electric Power and Water Board, Knoxville, Tenn.
Meyer, R. S., chief electrical engineer, Whitman, Requardt, Smith and Kuljian Company, Denver, Colorado.
Schindler, R. W., assistant professor of electrical engineering, Fenn College, Cleveland, Ohio.
Taylor, W. H., engineer, Bureau of Reclamation, Denver, Colorado.
Toole, M. G., electrical engineer, United States Navy Yard, Charleston, S. C.
Whitford, R. A., electrical engineer, and sales manager, ReQua Electrical Supply Company, Rochester, N. Y.
Wold, E. A., automatic chief, Western Union Telegraph Company, Minneapolis, Minn.
Woodford, A. G., research department, Allen Bradley Company, Milwaukee, Wis.

14 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical District. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before November 30, 1942, or January 31, 1943, if the applicant resides outside of the United States or Canada.

United States and Canada

1. North Eastern

Cassidy, G. E. (Associate re-election), General Electric Company, Schenectady, N. Y.
Hanfmann, A. M., Stone and Webster Engineering Company, Boston, Mass.
Harwell, H. W. (Member), Connecticut Telephone and Electric Corporation, Meriden, Conn.
McTear, C. K. (Member), Stone and Webster Engineering Corporation, Boston, Mass.
Russell, A. L. (Associate re-election), Franklin Technical Institute, Boston, Mass.
Smith, J. D., General Electric Company, West Lynn, Mass.
Symbolie, A. J., Watervliet Arsenal, Watervliet, N. Y.
Terpak, S., General Electric Company, Pittsfield, Mass.
Wentworth, C., The Acme Electric and Manufacturing Company, Cuba, N. Y.

2. Middle Eastern

Bennett, C. O., Bureau of Ships, Navy Department, Washington, D. C.
Bueno, M. deP., c/o Bureau of Inspection, Department of Labor and Industry, Harrisburg, Pa.
Caswell, A. S., I-T-E Circuit Breaker Company, Philadelphia, Pa.
Crain, C. M., Philco Corporation, Philadelphia, Pa.
Fessler, A. E., New York Shipbuilding Corporation, Camden, N. J.
Freed, L., Toledo Shipbuilding Company, Toledo, Ohio.
Gress, G. E., Automatic Temperature Control Company, Inc., Philadelphia, Pa.
Keck, C. L., Explosives Investigation Laboratory, Naval Powder Factory, Indian Head, Md.
Kleshick, F. P., New York Shipbuilding Corporation, Camden, N. J.
Lewis, D. D. (Member), Millville Manufacturing Company, Millville, N. J.
Lynott, W. J., Jr. (Member), Federal Power Commission, Washington, D. C.
May, C. W. H. (Associate re-election), Stone and Webster Engineering Corporation, Allenwood, Pa.
Moore, F. W., Bell Telephone Company of Pennsylvania, Pittsburgh, Pa.
Murphy, R. E., I-T-E Circuit Breaker Company, Philadelphia, Pa.
Roman, W. G. (Member), Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Patterson, J. R., The Austin Company, Painesville, Ohio.
Pattison, D. R. (Member), Pennsylvania Electric Company, Johnstown, Pa.
Petsonk, E., Westinghouse Electric and Manufacturing Company, Philadelphia, Pa.
Piper, J. F., New York Shipbuilding Corporation, Camden, N. J.
Smith, R. J. (Associate re-election), American Electrical Construction Company, Inc., Philadelphia, Pa.

3. New York City

Barrington, L. R., Brooklyn Edison Company, Brooklyn, N. Y.
Brady, P. F., Consolidated Edison Company of New York, Inc., New York, N. Y.
Coomes, J. H., Brooklyn Edison Company, Brooklyn, N. Y.
Doggett, R. J., The Foundation Company, New York, N. Y.
Gilford, E., (Associate re-election), Cox and Stevens, New York, N. Y.
Hoag, S. B. (Member), Chemical Construction Corporation, New York, N. Y.
Hochstadter, O. (Member), Lone Star Steel Corporation, New York, N. Y.
L'Allemand, C. C. (Associate re-election), General Electric Company, New York, N. Y.
Lucca, A., Brooklyn Edison Company, Brooklyn, N. Y.
Lynch, W. O. (Associate re-election), Jersey Central Power and Light Company, Morristown, N. J.
Perdiue, H. L., General Electric Company, New York, N. Y.
Ream, C. E., General Electric Company, New York, N. Y.
Reed, C. A. (Member), Board of Transportation, New York, N. Y.

4. Southern

Bertke, L. E., United States Army, Signal Corps, Camp Murphy, Fla.
Doub, T., Florida Power and Light Company, Sarasota, Fla.
Glyptis, N. (Member), The Girdler Corporation, Louisville, Ky.
Howe, E. S. (Member re-election), Federal Power Commission, Atlanta, Ga.
Jones, W. C., General Electric Company, Richmond, Va.
Sloop, J. L., National Advisory Committee for Aeronautics, Langley Field, Va.
Vaughn, A., Wilson Dam Hydro Plant, Wilson Dam, Ala.
Woodward, E. B., Navy Yard, Charleston, S. C.
Young, D. B., General Electric Supply Corporation, Shreveport, La

5. Great Lakes

Brem, H. C., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Copland, J. G., Tri-State College, Angola, Ind.
Fruth, H. F. (Member), Electro Manufacturing Company, Chicago, Ill.
Gancer, A. L., Oliver Farm Equipment Company, Plant #2, South Bend, Ind.
Graflan, P. S., Belmont Radio Corporation, Chicago, Ill.
Kiefert, E. E., Allis-Chalmers Manufacturing Company, West Allis, Wis.
Learman, J. C., Studebaker Aviation, South Bend, Ind.
Morehouse, E. G., Studebaker-Aviation Division, South Bend, Ind.
Mortensen, D. S., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Olson, B. R. (Associate re-election), Allis-Chalmers Manufacturing Company, West Allis, Wis.
Roller, J. A., Hercules Powder Company, Baraboo, Wis.
Satterfield, W. E., Ford Motor Company, Dearborn, Mich.
Swanson, A. F. H., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
York, V. O., Michigan College of Mining and Technology, Houghton, Mich.

6. North Central

Dingler, R. D., Monolith Portland Midwest Company, Laramie, Wyo.
Gaylord, E. H., Public Service Company of Colorado, Denver, Colo.
Hayami, F. Y., Engineering and Maintenance Office, Heart Mountain, Wyo.

7. South West

Abeles, M. C., City Light and Traction Company, Sedalia, Mo.
Bartels, M. W., Western Union Telegraph Company, St. Louis, Mo.
Brown, I., Missouri Electric Power Company, Marshfield, Mo.
Chaney, L. P. (Member), Lummus Company, Houston, Texas.
Cooper, E. A., Black and Veatch, Fort Smith, Ark.
Edmundson, C. W., Fluor Corporation, Kansas City, Mo.
Erskine, G. S. (Member), War Department, U. S. Engineers, Del Rio, Texas.
Fehlenberg, A. E., Union Electric Company of Missouri, St. Louis, Mo.
Lash, L. E. (Member), Fagan Electric Company, Little Rock, Ark.
McKeown, J. G., West Texas Utilities Company, Abilene, Texas.
Miller, S. L., Union Electric Company of Missouri, St. Louis, Mo.
Peake, H. S., West Texas Utilities Company, Abilene, Texas.
Schwearingen, F. L. (Member), Fischbach and Moore, Inc., Oklahoma City, Okla.
Silvus, W. E. (Associate re-election), General Electric Company, Houston, Texas.
Sutherland, D. J. (Associate re-election), Westinghouse Electric and Manufacturing Company, Houston, Texas.
Warner, W. W., Western Union Telegraph Company, St. Louis, Mo.

8. Pacific

Bloom, S. S. (Member), California Railroad Commission, San Francisco, Calif.
Jeffery, A. A., American Potash and Chemical Corporation, Trona, Calif.
Reed, W. M., Pacific Gas and Electric Company, Oakland, Calif.
Renner, J. J., U. S. Army Signal Corps, c/o Postmaster, San Francisco, Calif.

9. North West

Corfield, C. C., Puget Sound Power and Light Company, Dieringer, Wash.
Garnett, L. D., Nemco Electric Company, Seattle, Wash.
Jann, J. V., General Electric Company, Portland, Ore.
Johns, S. M., Westinghouse Electric and Manufacturing Company, Salt Lake City, Utah.
Macaulay, H., Puget Sound Power and Light Company, Dieringer, Wash.
Spain, C. J., Jr., Westinghouse Electric and Manufacturing Company, Portland, Ore.
Williams, W. J. (Associate re-election), Montana Power Company, Great Falls, Mont.

10. Canada

Ackroyd, S. G., Amalgamated Electric Corporation, Ltd., Toronto, Ont.
Bent, E. D., Northern Electric Company, Ltd., Montreal, Que.
Blackmore, C. L., H. G. Acres, Niagara Falls, Ont.
Fraser, J. P. (Member), B. C. Electric Railway Company, Vancouver, B. C.
Haltrecht, A., National Research Council, Ottawa, Ont.
Yee, T. M., Defence Industries Ltd., Nobel, Ont.

Total, United States and Canada, 101

Elsewhere

Pereira, M. P. deB., Radio Cinephon Brasileira, S. A., Rio de Janeiro, Brazil, S. A.
Vanderpoll, J. A. (Member re-election), S. I. A. M. Di Tella Ltda., Buenos Aires, Argentina, S. A.

Total, elsewhere, 2

OF CURRENT INTEREST

WAR PROGRAM • •

Industry Lends 3,000 Men to Salvage Campaign

More than 3,000 trained men, loaned by private industry to assist in the industrial salvage program, will make a 90-day plant-to-plant canvass of American industry and call on the presidents of 70,000 industrial firms in the most thoroughly organized search for industrial scrap to date, according to Robert W. Wolcott, chairman of American Industries Salvage Committee.

These men will co-operate closely with the industrial salvage section of the conservation division, War Production Board, to insure that all possible dormant scrap is collected. The field force of the industrial salvage section of the WPB has been doubled to comprise 140 men to handle this drive.

The program has been organized by the industrial salvage section under Hamilton W. Wright, through the regional chiefs of the WPB, and the American Industries Salvage Committee, headed by Mr. Wolcott. Executives of these organizations, heading up this special dormant scrap drive, are:

George Ross, secretary of the salvage committee of the American Iron and Steel Institute; Walter S. Doxey, president, American Steel Warehouse Association; C. F. Winchester, executive secretary, Associated Equipment Distributors, and H. R. Doughty, director of field operations on salvage for the National Federation of Sales Executives.

Continuous production from open-hearth and electric furnaces and other users of scrap during the winter months of 1943 is dependent on the collection of 7,000,000 additional tons of iron and steel scrap prepared for delivery to the mills for use during the winter months.

Theme of the drive for dormant industrial scrap is: "If it hasn't been used for the past three months and if no one can prove it will be used in the next three—find a use for it or scrap it."

WPB Curtails Variety in Types of Electric Lamps

Types of electric lamps that may be manufactured after November 1 are reduced from 3,500 to 1,700 by a recent order of the War Production Board. This order is expected to conserve seven per cent of the critical materials previously consumed in electric lamp manufacture and to result in considerable savings in manpower, manufacturing facilities, and storage space.

There is, however, no curtailment in the total production of electric lamps allowed, and it is expected that adequate supplies of the approved types will be produced to replace those no longer made. Some types will be eliminated in all categories of incandescent, fluorescent, and glow-discharge lamps, and manufacture of parts for these lamps is also to be discontinued. Colors are restricted to red, blue, and green.

The discontinued types of lamps fall into three groups:

1. Those for which suitable substitutes are available.
2. Those for which there is no essential demand.
3. Those formerly made in a variety of different voltages and wattages, which are now so simplified that only a small number of the previously made types will be needed.

Lamps designed for diagnostic and surgical purposes and those produced for the Army, Navy, Maritime Commission, War Shipping Administration, and Lend-Lease purposes are exempt from the WPB ruling.

It is expected that 650 tons of steel, 35,000 pounds of solder, and 8,000 pounds of tungsten will be saved for more urgent war production by the new ruling. Approximately 1,300,000 man-hours of direct labor will be released for production of radio tubes and other war products, and about 325,000 square feet of floor space will be made available for production of radio tubes and other electronic devices for the Army and Navy, plus about 400,000 additional square feet in warehouse space, as a result of the order.

Dry-Cell and Flashlight Production Curtailed

Control over production of dry-cell batteries and flashlights for civilian use and restriction of raw materials used in flashlight manufacture have been ordered by the War Production Board.

Smaller plants which do not have large military orders are permitted to manufacture batteries and flashlights for civilian use at a greater rate than larger plants, which, for the most part, are operating at capacity on orders for the armed forces. Flashlights and other portable electric lanterns in the hands of manufacturers will be released primarily for industrial use, and then only for orders bearing a preference rating of *A*-10 or higher.

The new order prohibits the use of tinplate and terneplate in flashlight fittings, tinned copper wire for electric contacts in dry-cell batteries, iron and steel in battery outer jackets and top and bottom seals, and copper and copper base alloy except in wire and brass plating, and limits the use of zinc in dry-cell batteries.

Only 35 per cent of the number of radio batteries produced in 1941 will be manufactured, primarily for use on farms. Batteries for the portable-type radio are entirely eliminated as nonessential.

Production of flashlight batteries will be cut one half compared with 1941 output. Other types of dry-cell batteries will be reduced ten per cent, except that batteries for hearing aids and railroad lanterns will be produced in greater quantity until December 31, 1942. Output of flashlights and other types of portable electric lights will be $^{1}/_{50}$ of what it was in 1941.

It is estimated that about 8,000 tons of zinc will be saved for the war effort, approximately 1,000 tons of copper, and several hundred tons of steel, compared with 1940 consumption. The new order also will release much needed production facilities for military purposes.

WPB Names Committee to Plan Setup of Technical Branch

Appointment of a committee of engineers and scientists to determine the manner in which the projected Office of Technical Development should be set up within the War Production Board, and to define the scope, functions, and method of operations which the office should have, was announced today by WPB Chairman Donald M. Nelson. Decision to establish such an office was made earlier, following a report by a previous committee recommending that the War Production Board set up a strong scientific and technical organization to make sure that the nation's technical ability and resources are utilized to the full in the war-production program.

Chairman of the new committee is Webster N. Jones, director of the college of engineering, Carnegie Institute of Technology, Pittsburgh, Pa. Other members are:

Lawrence W. Bass, director of research, New England Industrial Research Foundation, Boston, Mass.; Oliver E. Buckley (F '29) president, Bell Telephone Laboratories, New York, N. Y.; Colonel Clarence E. Davies, Ordnance Department, United States Army, Washington, D. C.; Ray P. Dinsmore, manager, development department, The Goodyear Tire and Rubber Company, Akron, Ohio; Admiral J. A. Furer, United States Navy, Washington, D. C.; Jerome C. Hunsaker, head of the departments of mechanical and aeronautical engineering, Massachusetts Institute of Technology, Cambridge, Mass.; H. W. Graham, director of metallurgy and research, Jones and Laughlin Steel Corporation, Pittsburgh, Pa.; S. D. Kirkpatrick, editor *Chemical and Metallurgical Engineering*, New York, N. Y.

Silver Replaces Copper. Substitution of silver for copper in electric conductors, such as bus bars and windings for transformers, has saved 24,000,000 pounds of copper for the war program in the last few months, the War Production Board announces. A minimum of 34,000 tons of silver has been allotted to the Defense Plant Corporation by the United States Treasury and must be returned after the war. The Defense Plant Corporation is lending this silver to those

plants that must have large quantities for operation, that can conveniently protect the silver, and that are in operation almost constantly. The silver is made available with the stipulation that it can be used only for a nonconsuming purpose.

IT and T to Expand Factory Facilities. The International Telephone and Telegraph Corporation has announced plans to proceed with construction of the first unit of a new factory, which will eventually become the home of that company's research and manufacturing operations in the United States. The factory will be constructed in units following a fundamental plan which is planned to provide great flexibility for expansion. Each unit will be self-sufficient and yet will be designed so as to be co-ordinated with the other units to form an efficient and modern plant. The new unit is expected to contain about 75,000 square feet of operating space.

Electricians Trained in Quartermaster Corps

One of the chief services performed by trainees in the electricians' school of the United States Army Quartermaster Corps, Camp Lee, Va., is repair work and maintenance of electric wiring. Trainees of the school, which is conducted in 12 technical training shops, have installed the wiring in two laundry units and a mobile clothing and shoe-repair unit, have instituted the public-address units and the camp-wide broadcasting network, and set up and are now expanding the communication systems used on the post.

The school, taught by a staff of experienced noncommissioned officers, takes trainees who for the most part have had some previous experience as electricians and adapting civilian experience to Army needs, turns out the students with ratings of skilled, semiskilled, or helpers, according to their versatility as electrical technicians.

Instruction in the electricians' school is both practical and varied. Eighty per cent of the time is allotted to practical work, either experiments with the various machines in the shop, or repairing of installations about the post, as in the accompanying illustration; the remainder is devoted to lectures with emphasis placed on the practical in preference to the theoretical.

EDUCATION . . .

Stevens Institute Assumes Charge of Edison Tower

The Edison Tower at Menlo Park, N. J., erected on the site of Thomas Alva Edison's original laboratory, was placed in the keeping of Stevens Institute of Technology recently by its donor, William Slocum Barstow (F '12).

Doctor Harvey N. Davis, president of the college, headed a group of college officials making an inspection of the 131-foot structure, with its airplane beacon blacked out because of the war. The eternal light inside which was lighted by Edison himself still burns.

A bill passed by the New Jersey state legislature provided for transferring operation and maintenance of the tower and grounds from the Thomas Alva Edison Foundation, Inc. to Stevens Institute. Perpetual maintenance of the tower is guaranteed through a trust fund.

Mr. Barstow told, during a recent inspection of the tower, of how he had conceived the plan for it in 1929, while he was working with Henry Ford at Dearborn, Mich. At that time he intended it to be a temporary structure, to commemorate Edison's activities at Menlo Park from 1876 to 1886. The center of the tower was the exact location of the work bench at which the inventor had perfected the first incandescent lamp. The temporary steel tower was built and the 900 lamps in the large bulb at the top were lighted by Mr. Edison from Dearborn, Mich., on October 21, 1929, on the occasion of light's golden jubilee. In 1937 Mr. Barstow decided to replace the temporary tower with a permanent structure. "Mr. Ford urged me to construct the new tower around the temporary tower, so the new lamp could be lighted from the old, and to remove the old tower from inside the permanent tower later on," said Mr. Barstow. "In this way we hoped to preserve the light Mr. Edison had lighted, although it involved difficult methods of construction."

The permanent tower was completed and dedicated February 11, 1938, the 91st anniversary of Edison's birth. The beacon which surmounts the structure is a replica of the original incandescent lamp and when lighted, before the dimout was in effect, could be seen for many miles. The tower also contains loud speakers used as an address system, which also broadcast records of chimes and other music over a radius of two miles, in recognition of the fact that here, too, Edison invented the phonograph.

50th Anniversary of Manhattan Engineering College

A special convocation was called to commemorate the 50th anniversary of the founding of the school of engineering at Manhattan College, New York, N. Y., on October 14, 1942. In addition to the student body and alumni, the convocation was attended by dignitaries of the Catholic Church and delegates from other educational institutions and from learned societies. Honorary degrees of doctor of engineering were conferred on Commander E. H. Praeger, United States Naval Reserve, R. C. Muir (F '36) vice-president in charge of engineering, General Electric Company, Schenectady, N. Y., and F. H. Zurmuhlen, chief engineer, Walsh Construction Company, and George F. Driscoll Company. Most Reverend Francis J. Spellman, Archbishop of New York, presided.

The celebration began with an academic procession after which the Reverend Brother A. Victor, president of Manhattan College, extended the official welcome. Following his remarks, Mr. Muir delivered an address on the subject, "The Industrial Aspects of Technology—Effect Upon Economic and Social Structure With Emphasis on Present Planning and Future Readjustment." Brief remarks by Archbishop Spellman brought the ceremonies to a close, after which dinner was served to the delegates and guests.

Characterizing technology as a two-edged sword, Mr. Muir in his address declared that our superior technology will enable us to win the war, and that we must also win peace. "This will require co-ordinated planning," he continued, "in industry, in farming, in trade, in education, in the professions, in our churches, and in our government. It will require co-operation between government, industry and agriculture....

"We must, I believe, have government and industry working together in full co-operation, with confidence in each other, and with full recognition of their mutual interdependence and mutual responsibilities. Barriers between groups must be removed....

"If we are to obtain and maintain a long range plan to which we may work, we must have some of the ablest men in the country devoting their lives to this task. Perhaps we might have a fourth branch of government, a department of planning, or, if you prefer, of social and economic development. Its members would have the standing of justices of the Supreme Court, and its functions would be to advise the President, Congress, and the various department agencies of the government. With able men devoting their lives to the planning of the social and economic welfare of the nation, we might face the future with better hope and confidence.

"And because technological developments, particularly in the radio and the airplane, have made the world a smaller place in which to live and have brought its people closer together, we must also have some international plan of co-operation. If we are to have continuing peace throughout the world, we must have continued economic and social progress in all nations, equally, and in no nation at the expense of others. . . .

"Let us not forget that technology is not an end, but merely a means," Mr. Muir concluded. "It is man himself who is the end, and this is the true dignity of man."

"Slide Film" Aids in Teaching Fundamentals of Electricity

The ever-growing demand for more electrically trained and electrically skilled man power for the various phases of the war effort, has necessitated the creation of some method which shall serve to teach the fundamentals of electricity in the shortest possible time, because little can be done to hasten training in the more advanced and practical electrical specializations. One means of shortening the period of elementary training in electricity now being used throughout the United States by vocational and science teachers, in high schools and colleges as well as in industry, is the new "slide-film" set which consists of 12 "slide-film" productions designed to provide the beginner with an elementary knowledge of basic electricity.

By the visual medium it is believed that students get a clearer picture of the complexities of basic electricity in a much shorter time than is possible by lecture alone or by text-books alone. The films of themselves, however, are not designed to give students a complete course in the fundamentals of electricity. Rather they have been prepared to provide a broad background of principles upon which the instructor may build up to the point of specialized study.

There is a total of 837 individual pictures on the 12 filmstrips, including drawings, diagrams, photographs, graphs, and exhibits. Each individual picture carries with it, on the picture screen, explanatory text and captions which serve to aid the instructor, who may elaborate on or discuss each point as it is made visually. Each film is a separate subject, and may be shown alone or in the series. They are of the discussional type, and instructors may set the speed of projection to any pace desired.

The subjects of the 12 films available are:

1. Magnetism—the general laws and properties of magnets; magnetic effects.

2. Static electricity—the electron theory of positive and negative charges.

3. Current electricity—laws of current flow in the various types of circuits.

4. The electric cell—the change of chemical energy into electrical energy; primary and secondary cells.

5. The storage battery—the construction and use of the commercial storage battery.

6. Electromagnetism—construction and use of the electromagnet; effects of the electromagnetic field.

7. The generator—principles of the generator; types; generating direct and alternating current.

8. Alternating current—inductance, capacitance, and impedance in a circuit; transformers and rectifiers.

9. Electric motors—principles of the motor, d-c and a-c motors; universal motors.

10. Electric meters—construction and operation of various types of meters for electrical use.

11. Applications—heating and lighting.

12. Applications—solenoids, motor uses, radio, and electroplating.

All inquiries relating to these films should be addressed to the distributors, The Jam Handy Organization, 2900 East Grand Boulevard, Detroit, Mich.

HONORS • • • • • •

John Fritz Medal Awarded to Willis R. Whitney

Willis Rodney Whitney (A '01) chemist, engineer, inventor, author, and educator, and vice-president in charge of research, General Electric Company, Schenectady, N. Y., has been announced as the recipient of the 1943 John Fritz Medal, the highest American engineering award. Dr. Whitney has been awarded the medal "for distinguished research, both as an individual investigator and as an outstanding and inspiring administrator of pioneering enterprise, co-ordinating pure science with the service of society through industry."

First bestowed in 1902 to John Fritz of Bethlehem, Pa., pioneer iron-master and engineer in whose memory the award was established, the John Fritz Gold Medal is awarded annually for "notable scientific or industrial achievement, without restriction on account of nationality or sex." It is a joint honor, conferred by a board composed of representatives of four national societies, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. The medal funds are administered by United Engineering Trustees, Inc., joint organization of these four societies.

Details of Doctor Whitney's professional career appear in a "Personal" item on page 574 of this issue.

Swope Awarded Hoover Medal

Gerard Swope (F '22) electrical engineer and honorary president of General Electric Company, New York, N. Y., has been announced as the recipient of the sixth Hoover Gold Medal. Details of Mr. Swope's professional career are given on pages 574–5 of this issue.

The Hoover Medal was formally instituted in 1930, to commemorate the civic and humanitarian achievements of Herbert Hoover (HM '29) to whom the first award was made. The successive recipients have been Ambrose Swasey (HM '28) in 1936, and John Frank Stevens in 1939. The board of award consists of representatives of four national societies, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers.

OTHER SOCIETIES •

AWS President Urges Less Censorship on Research

Less strict censorship of the results of scientific research was urged in the annual report of the welding research committee of the Engineering Foundation, a committee sponsored by the American Welding Society and the American Institute of Electrical Engineers. The committee's voice against censorship was raised by Colonel G. F. Jenks, president of the society during 1941–42, and chairman of the committee's industrial research division, who stated that "the division is beginning to feel the results of restrictions in the publication of information because of government censorship," and that "it believes that the greatest benefits to war production and to victory in the field will result from a liberal policy through which the results of research will be disseminated immediately to American engineers and scientists."

The committee, headed by C. A. Adams (F '13) consulting engineer, Edward G. Budd Manufacturing Company, of Philadelphia, Pa., reviewed the large number of studies on the various questions of welding, which it completed or carried on during the year ending October 1, 1942. The results of these studies were discussed at the fundamental research conference of the American Welding Society on October 12, 1942, during the society's convention in Cleveland, Ohio.

The welding research committee pointed out in its report that "more than ever, it needs the support of industry to dig a little more deeply into some fundamentals which cannot be strictly labeled immediate war needs but which, in the long run, will assist in the war effort and in peacetime activities. Dozens of instances could be cited where this support is of paramount importance." The committee has relinquished some of its activity to the federal government, and is co-operating in an advisory capacity.

The committee's literature division, headed by H. C. Critchett, "made available the best existing knowledge of European methods of welding armor plate and other alloy steels," thus enabling "our experts to take into account the best way of saving strategic alloying elements without sacrificing weldability and the necessary physical properties."

The fundamental research division, chairman of which is H. C. Boardman of Chicago, Ill., "saved at least nine months

of precious time by realizing that it would be necessary to predict the weldability of any new steel and specify the exact procedure to follow in order to get the best results. As a consequence it outlined and initiated a program of fundamental research in spite of serious financial obstacles," according to the recent statement of the committee.

The industrial research division organized new committees and adjusted activities of the existing committees in its organization to solve many problems relating to resistance welding, aircraft applications, and the subjection of welds to dynamic stresses.

ASME Elects 1943 Officers

The American Society of Mechanical Engineers recently announced its 1943 officers, who are to be installed during the society's 63d annual meeting, November 30–December 4, 1942, in New York, N. Y. The new officers are:

President: H. V. Coes, vice-president, Ford, Bacon and Davis Inc., New York, N. Y.

Vice-presidents, elected to serve a two-year term—J. W. Eshelman, president, Eshelman and Potter, Birmingham, Ala.; T. E. Purcell, general superintendent, power stations, Duquesne Light Company, Pittsburgh, Pa.; G. T. Shoemaker (F '39), vice-president, Kansas City Light and Power Company, Kansas City, Mo.; W. J. Wohlenberg, professor of mechanical engineering, Yale University, New Haven, Conn.

Managers: R. W. Morton, professor of mechanical engineering, Head of Department, University of Tennessee, Knoxville, Tenn.; A. E. White, director of engineering research, University of Michigan, Ann Arbor, Mich.; A. R. Stevenson, Jr. (F '37), staff assistant to vice-president, General Electric Company, Schenectady, N. Y.

Industrial Research Institute Meeting Held

The Industrial Research Institute held a meeting in Buffalo, N. Y., on September 4–5, with 75 industrial executives and research directors, representing member companies, and their guests attending. Principal speakers for the two day convention were Frederic Flader, chief engineer of Curtiss-Wright Corporation, Buffalo, N. Y., and C. E. K. Mees, vice-president and director of research, Eastman Kodak Company.

Papers on patent trends and pending legislation, reviewed by H. S. Demaree, head of the patent department, The Hoover Company, Chicago, Ill., and on the production requirements plan and its effect on research laboratories, outlined by E. R. Schaeffer, chief of the safety and technical equipment branch, War Production Board, Washington, D. C., were among the problems of research management discussed. The mass spectrometer as a new research tool was also described by Harold Washburn, Consolidated Engineers, Pasadena, Calif.

An inspection trip was routed through the new assembly plant of the Curtiss-Wright Corporation in Buffalo, where the group witnessed performance tests of the P-40 pursuit planes produced by this company.

The Institute, an affiliate of the National Research Council, undertakes to promote improvement of methods and more economical and effective management in industrial research through the co-operative efforts of its members. The membership is composed of 46 industrial concerns maintaining research laboratories. Their top executives in charge of research represent them in the activities of the Institute. Its headquarters are at 60 East 42nd Street, New York, N. Y., having been moved recently from Chicago, Ill.

Future Meetings of Other Societies

American Chemical Society. National Chemical Exposition and National Industrial Chemical Conference, November 17–21, 1942, Chicago, Ill.

American Institute of Chemical Engineers. 35th annual meeting, November 16–18, 1942, Cincinnati, Ohio.

American Institute of Mining and Metallurgical Engineers. Annual meeting, February 14–18, 1943, New York, N. Y.

American Physical Society. 251st meeting, November 27–28, 1942, Chicago, Ill.; 252d meeting (annual) December 28–30, 1942, New York, N. Y.; 253d meeting, December 29, 1942, Los Angeles, Calif.

American Society of Civil Engineers. Annual meeting, January 20–22, 1943, New York, N. Y.

American Society of Mechanical Engineers. Annual meeting, November 30–December 4, 1942, New York, N. Y.

Society of Naval Architects and Marine Engineers. 50th annual meeting, November 11–14, 1942, New York, N. Y.

JOINT ACTIVITIES

ECPD Adopts Resolution on Use of Engineering Man Power for War

At a meeting on September 20, 1942, in New York, N. Y., the executive committee of the Engineers' Council for Professional Development passed the following resolution relating to the distribution of engineering man power in the United States armed forces and in industry:

In modern, mechanized warfare, the need for engineers and scientists in war industries and in the fighting forces is out of all proportion to the relatively small number available, or in prospect. This is particularly true of the United States which must not only supply its own forces but serve as an arsenal for the democratic forces of the world. It is, therefore, of vital importance to the country both to conserve this talent and to distribute it where it will best serve the total war effort. Other countries have already found this necessary.

The waste of technical talent by its diversion to services where technical skill is not essential or by a failure to use the available training facilities to the full can add but little to the man power of the armed forces and may do irreparable damage; for, without adequate technical equipment and skill armies and navies are helpless.

To meet this situation, the following steps should be taken:

1. Conserve and put to most effective use existing staffs of engineers in the industries producing war materials and in the engineering schools training young men for specialized services in the armed forces and in the war industries.

Welders to Aid in War Production

These streamlined Flexarc welders in the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., mounted on wheels so as to be moved easily from place to place, are destined for shipyards, airplane plants, and other war factories.

2. Adapt all engineering, science, and management courses in colleges to the needs of war, both in the armed services and in war industries.

3. Allocate engineers to each war activity on the basis of its relative needs, considering both the armed forces and the war industries. This allocation process should provide for those who plan to study engineering, for engineering students, for engineering teachers, and for engineers of mature experience.

4. Encourage women to undertake engineering and science courses in college.

5. Continue the support of the Engineering, Science, and Management War Training program.

6. Recognize the fact that the assignment of all able-bodied engineers to the armed forces where some may be called on to render service in fields where their training will not be used is a misdirection of skill and is not in the best interest of the total war effort.

ASA Issues Letter-Symbols Standard

A new American Standard, Letter Symbols for Mechanics of Solid Bodies of 10.3-1942 has been approved and published by the American Standards Association. In addition to the 68 letter symbols approved to indicate such concepts as angular acceleration, circular frequency, factor of safety, normal strain, wave length, and the like, the new standard cites general principles of letter-symbol standardization governing manuscripts, subscripts, superscripts, unlisted magnitudes, and typography.

The new standard, available from the ASA, 29 West 39th Street, New York, N. Y., at 25 cents per copy, was prepared by the ASA sectional committee on letter symbols and abbreviations for science and engineering, under the joint technical leadership of the American Association for the Advancement of Science, the American Institute of Electrical Engineers, the American Society of Civil Engineers, the Society for the Promotion of Engineering Education, and The American Society of Mechanical Engineers.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without letter, the other lettered. Captions should be supplied for all illustrations.

Characteristics of Driven Grounds

To the Editor:

In his letter in the February 1942 issue of *Electrical Engineering*, pages 106–7, on a paper by P. L. Bellaschi, on "Impulse and 60-Cycle Characteristics of Driven Grounds," which appears in the AIEE *Transactions*, volume 60, 1941, (March section) pages 123–8, W. H. Treadway makes certain mathematical deductions relating to the response of ground electrodes to surge voltages which are based on the assumption that the ground rod is equivalent to an inductance and resistance (corresponding to the earth path) in series with an imperfect capacitor (corresponding to the contact between the metal and the soil). It has been shown by G. F. Tagg,[1] however, that this is only partially correct; the soil surrounding a rod possesses both resistance and capacitance, but these are distributed throughout the body of the soil and the equivalent circuit is rather like that of a transmission line, with the difference that whereas with the latter the resistance and capacitance per unit length are usually constant, with the ground rod the resistance and capacitance per unit distance from the rod are not constant owing to the increase of effective area through which the current flows.

Evidence for the existence of this distributed capacitance is based on extensive tests from which Tagg showed that the a-c specific impedance of a body of soil was always less than, and bore a constant relation to, the d-c specific resistance. From this relationship it is possible to relate the effective dielectric constant of soil to its specific resistance, and astonishingly high values of from 100,000 to 1,000,000 were obtained, thus confirming earlier work by R. L. Rose-Smith.[2]

Contact resistance was once thought to be the only resistance of importance with earth electrodes. O. S. Peters[3] exploded this idea but his tests on contact resistance were not quite sufficiently sensitive, and we found a few years ago, in this country, that in certain cases there did seem to be a small contact resistance. Tagg's tests, however, settled the matter and showed definitely that there was a small contact impedance which was less with alternating current than with direct current and was less at 50 than at 25 cycles per second. This impedance, in both its resistance and capacitance components, varies with the type of soil, the pressure and the nature of the surface, and material of the ground electrode, but it is of such a magnitude as to have no practical bearing on the operation of normal-sized ground rods. In some model tests on the distribution of potential around ground electrodes of various shapes, for which I was partly responsible, the contact impedance at 50 cycles per second was comparable with the total impedance and was only eliminated by making the tests at 3,500 cycles per second, but these electrodes were measured in centimeters, whereas actual ones are measured in feet, and the larger the electrode the smaller the ratio of the contact impedance to the total impedance. Tagg's results showed that for a 6-foot electrode one-inch diameter, the contact resistance is about five per cent of the total ground resistance.

Mr. Treadway is not quite correct in saying that ground rods in parallel do not follow the normal law for resistances so connected; they do if they are sufficiently far apart. Whether it is better to connect rods in parallel or drive them deeper depends entirely on the variation of soil resistivity with depth and on the nature of the soil; sometimes one method is better, sometimes the other.

There is no evidence that the resistivity of soil varies with the magnitude of the current—if we except changes due to polarization, heating, or dielectric breakdown. This was shown by C. P. Sparks as long ago as 1915, when he made tests with currents from 4 to 290 amperes.

While it is admitted that there is much yet to be learned, about ground electrodes, particularly in respect of their behaviour under surge conditions, I hardly think that the subject is in such an early stage of development as Mr. Treadway suggests, and neither do I think that any remarkable changes of practice are very likely.

REFERENCES

1. The Contact Impedance of an Earth Electrode, Part I, **G. F. Tagg.** *World Power*, volume 26, July 1936, pages 9–12; Part II, August 1936, pages 52–5.

2. Electrical Measurements on Soil With Alternating Currents, **R. L. Rose-Smith.** Institution of Electrical Engineers *Journal*, volume 75, August 1934, pages 221–37.

3. Ground Connections for Electrical Systems, **O. S. Peters.** Technological Papers, United States Bureau of Standards, publication number 108.

H. G. TAYLOR
(Electrical engineer, London, England)

Terminal Corrections for Temperature Tests on Short Samples

To the Editor:

In many temperature tests of electric wires, cables, and other equipment, the conductor and the external cooling medium are approximately uniform over the length of the sample, but the temperature at the ends differs from that at the mid-point because heat is added or extracted by the terminals. In a short sample this causes errors in the results. The following simple method can be used to correct such readings, to show that no correction is needed, or to estimate proper sample lengths.

The conductor is assumed to have constant heat input per unit length, and to have heat added or extracted at a constant rate at its terminals. Cooling is assumed to be proportional to temperature difference between conductor and surrounding medium (usually air). Temperatures along the conductor can then be represented fairly accurately by voltages along a long d-c transmission line having uniform linear resistance and shunt conductance. Heat input (or extraction) by the terminals of

the sample causes a temperature rise (or drop) which diminishes exponentially with distance from the terminal. The error in measured temperature at any point, due to end effect, can therefore be calculated if the mid-point and terminal temperatures, and the attenuation, are known. Similarly, the required length of sample to reduce the error in mid-point temperature to any desired percentage of the terminal disturbance, can be estimated.

Under the assumed conditions,

α = attenuation per inch $=\sqrt{rh}$

r is the thermal resistivity of the conductor at the test temperature, degrees centigrade per inch per watt.

h is the heat-transfer coefficient between conductor and cooling medium, watts per inch per degree centigrade temperature difference.

This can be written,

$$\alpha=\frac{I}{A}\sqrt{\frac{\rho}{k\ (\text{deg C rise})}}$$

I is the current, amperes.

A is the conductor cross-section, square inches.

ρ is the specific resistivity of the conductor material at the test temperature, ohms per inch-cube.

k is the thermal conductivity of the conductor at the test temperature, watts per degrees centigrade per inch-cube.

(deg C rise) is the average temperature rise of conductor above cooling medium.

For example, with 570 amperes in a 30-foot loop of number 3/0 copper transmission wire, measured temperatures were 133 degrees centigrade at the mid-section, 60 degrees at the terminals, 29 degrees in the air.

Then

$$\alpha=\frac{570}{0.132}\sqrt{\frac{0.70[1+0.00382(113-20)]10^{-6}}{9.7(133-29)}}=0.135$$

Calculated temperatures along the wire therefore are

Degrees centigrade at x inches from a terminal $=133-[133-60]\epsilon^{-0.135x}$

A comparison of calculated and measured values at several points is shown in the accompanying table.

x	Degrees C (Calculated)	Degrees C (Measured)
0	60	60
2	77	70
5	96	94
8	108	110
15	124	125
22	129	127
118	133	133

Several other experimental checks seem to show that the method is sufficiently accurate for practical purposes. If the temperature disturbance at the mid-point of a sample is to be limited to one per cent of that at the terminals, the minimum sample lengths range from about 4 feet for number 4 copper wire, to 12 feet for 75,000 circular-mils conductor. For steel wire the samples need be only 1/4 as long as for copper; if the test is made in moving air (wind velocity 5–10 mph) the above figures can be halved. For water-cooled conductors the attenuations become roughly ten times those in air, and samples can be very short.

FREDERICK BAUER (A '42)
JEROME J. TAYLOR (A '40)

(Detroit (Mich.) Edison Company)

Effect of War on Young Engineers Inducted Into Industry

To the Editor:

The many inquiries coming to me from young engineers seeking advice on their part in the war effort and the developments in United States Government policy since my talk, "The Effect of War on Young Engineers Inducted Into Industry" (*EE, June '42, pp. 281–2*), given at the AIEE North Eastern District meeting, Schenectady, N. Y., in May 1942, prompted me to write you this letter.

In the first place, it is increasingly clear to everyone that all of us in the United States are now in government service for the duration of the war. Some of us are in the armed forces and others in the industrial army that is so vital for the development and production of the highly technical material necessary in modern warfare. It is essential that a proper balance of skilled personnel be maintained in both of these armies, although the balance between them will vary with the progress of the war.

Some uncertainties have existed between the government and industrial people regarding the allocation of technical graduates to the armed forces and industry, but these are now clearing up. At least, it appears increasingly clear that highly skilled and trained people in industry must not be indiscriminately taken by the armed forces. For example, a recent letter indicates that the United States Navy has decided not to accept for enlistment any one classified as II*A*, II*B*, or III*B*, without first receiving notice from the registrant's local board that he is released for enlistment. This provision does not apply to officer candidates, however.

Young men in the industrial field should fix clearly in their minds the fact that they too are in the Army. It is quite essential that they consider classifications made by their Selective Service boards as orders from their government regarding their status. If a young man is placed in II*B*, it is very clearly an indication that he has been ordered by his government to remain in his industrial job until such time as his Selective Service board considers him for actual induction in the Army (after all of the steps that may be involved in appeals, through the State Appeal Boards, the State Directors of Occupational Deferment, and even to the Selective Service in Washington, D. C.).

Young engineers should also have a clear understanding of the operation of Selective Service, especially the results which occur when they make applications for commissions. Many a young man assumes that, as soon as he is notified to report for a physical examination, induction is inevitable, and so he takes steps to apply for a commission. He must realize, however, that a necessary part of the procedure in applying for a commission, if he is occupied in a war industry, is that he must secure a letter of release from his employer. Naturally, a letter of release to the Army or Navy for an officer's commission must be accompanied by a similar letter to his Selective Service board.

In other words, when a young man applies for a commission, his company must withdraw the request for deferment, and his local board naturally immediately places him in Class I*A*. If, then, for any reason, the applicant does not pass the rigid physical examination required for a commission, he is immediately available for induction under his I*A* classification. His employer, having once released him, cannot conscientiously again request deferment. A number of young engineers have had this experience, and have had the choice of actual induction or immediate enlistment.

There are only some 300,000 engineers in existence in the whole United States. The United States Navy alone has stated its needs during the next few years as high as 80,000 technically trained men per year. This latter number is approximately equal to the average total graduates of all the colleges of the United States in recent times. Hence, it is evident that there is an extreme shortage of technically trained people. Electrical engineers are especially in demand because of the great expansion of radio and the growing use of electrical devices by the armed services. It is, therefore, very unfortunate for us to waste technical man power by placing such men on ordinary military duty. It is exceedingly difficult, because of the large number of people involved, for the Army or Navy to identify technically trained individuals who enter service by induction, unless they are brought to the attention of the authorities by those who have good knowledge of their abilities. Men who are so identified and who are found properly qualified are normally placed in officers' training schools by the Army or the Navy, and are commissioned after a due period of training.

It is, therefore, the duty of all employers of engineers, when a young man is inducted, to call to the attention of the proper authorities in the various branches of the service the fact that he is technically trained and has certain useful experience and to suggest that he be placed in a position where his technical training can be used effectively. Not a single case of a technically trained young man coming up for induction should occur without a real effort being made to

see that the individual is properly placed. Not only employers, but also the officers of the Founder engineering societies, should be glad to help in this way.*

The advice which should be given to young men occupied in the war industries is that they should not enlist, nor apply for commissions, until their consciences clearly dictate to them that they can be more effective in the war effort in the Army or Navy than they would be in industry. They should be advised that their pride should have nothing to do with such a move. Criticisms by other people because they are not in uniform will not help the war. They should also be assured that, if and when they are inducted, every possible step will be taken to see that they are brought to the attention of the proper authorities (as officer material). They should be reminded that qualified people are normally commissioned in a very short period of time.

In other words, each man should fully inform his employer and his Selective Service board of his abilities, his experience, and his ambitions, and then accept whatever classification he is placed in. Having done this, he should put all his energies into doing the job assigned him, whether it be in the industrial army or the armed services.

M. M. BORING

(Engineering general department, General Electric Company, Schenectady, N. Y.)

* *Editor's note:* For this purpose AIEE headquarters will supply to any member upon request a statement regarding his AIEE membership, technical papers presented and published, and so forth.

Compression and Oil-Filled Cable Versus Gas-Filled Cable

To the Editor:

Having initiated the practical use of mechanical pressure for the improvement of underground power transmission, I have a few comments on the two papers, "120-Kv Compression-Type Cable" and "120-Kv High-Pressure Gas-Filled Cable," by I. T. Faucett, L. I. Komives, H. W. Collins, R. W. Atkinson, published in AIEE *Transactions*, volume 61, September section, pages 652–7 and 658–65, respectively. No impartial reader of the two papers can escape the conclusion that they do not present a fair comparison of the two types of cable. Much trouble has been taken by the authors to show that the impulse breakdown strength of the gas-filled cable is comparable to that of the compression and oil-filled types. However, this result was obtained by incorporating special features and particular precautions into the manufacture of the gas-filled cable without doing the same thing for the compression cable and then comparing the results with each other and also with the results obtained on other types of cable for which those special features and precautions have not been provided. A fair comparison, of course, can only be obtained if comparable things are compared with each other; evidently those thoroughly known features and precautions, if taken for the other types of cable would improve their performance also so that the comparison with the gas-filled type would be different and to the disadvantage of this latter type.

Then there is the question of a cable without lead sheath. European engineers do not believe in the necessity of a lead sheath, whereas engineers in the United States do. In fact we have hitherto abhorred designs for extra-high-voltage cables where the insulation is bared to the atmosphere and then pulled into a pipe to operate directly in contact with whatever may be in that pipe, for instance rust, moisture, residual air, oil or gas under pressure. With this also is connected the question of the return path for fault currents and certain unfortunate experiences both in Europe and in America when such a path was not provided for sufficiently by a lead sheath appropriately designed. I remember very well that such experiences occurred in Europe when the *H*-type cable was introduced there so that it was necessary to prove by test results that the contact between metalization and lead sheath was good enough to prevent the metalization from carrying heavy currents on a considerable distance and thereby burn.

The comparison of Figure 7 in the paper on compression cable with Figure 2 in that on gas-filled cable shows a considerably higher power factor for the gas-filled cable than for the compression cable, namely 0.5 to 0.8 as against 0.4 to 0.5, respectively. Is this perhaps accidental?

The gas-filled cable seems to have been designed for a maximum stress of about 7.3 kv per millimeter in operation as against 8.9 kv per millimeter for the compression cable. These figures have to be compared with the corresponding long time breakdown stress value of 16 kv per millimeter and 40 kv per millimeter, respectively. Therefore, the gas-filled cable has a much lower safety factor than the compression cable as both cables have been designed in this case.

From Figure 13 of the paper on gas-filled cable it may be seen that the voltage-time curve of the gas-filled cable is very much the same as that curve of a solid-type cable. The general shape of this curve in Figure 13 and also its numerical values are about the same as those well known for solid-type cable; it takes something of the magnitude of 100 hours to reach the final long-time value in both cases whereas this value is reached after very few hours (two to five) for the compression cable and also for the oil-filled cable. These similarities are certainly not accidental but they show that the mechanism of breakdown must be of the same kind for solid-type and gas-filled type on one side and different from the mechanism of breakdown of compression cable and oil-filled cable on the other side; the phenomena of ionization and deterioration which lead to the breakdown of solid-type cable must, therefore, also be present in the gas-filled cable.

With a view to what is said above, it seems justifiable to question the necessity and purpose of proposing and propagating a type of cable which in several important respects is decidedly inferior to the compression cable as, for instance, in electrical performance, heat radiation, repairs, and also, price if calculated and designed on the same basis. It is particularly interesting to ask why one should go to the complications connected with stripping off the lead sheath of a cable during installation and producing an inferior structure instead of leaving this lead sheath where it is and having a simpler installation and a better power transmission with a long time a-c breakdown strength $2^1/_2$ times higher than if the lead sheath is stripped off.

Regarding the operating record of both types we come to a similar conclusion, namely that the gas-filled cable can scarcely compete with the compression cable. This can be easily verified from the literature of the compression cable in the last ten years. By the way, it was in October just ten years ago that the first important installation of compression cable was put into service in England and this line has been working these ten years, I should say, more satisfactorily than can be expected of a first installation of such importance and of such an entirely new and revolutionary design. In this particular case a normal 33 kv cable according to the then prevailing English standards was used, put into a steel pipe and operated under pressure at 66 kv without resorting to the precautions and complications described in this paper for the manufacture of the gas-filled cable. This first compression cable in England has also gone successfully through some heavy bombing during the battle of England. I just want to put this here on record as the authors of the compression cable paper omitted to do so.

I take it that these papers on compression cable and on gas-filled cable are, in a sense, preliminary publications on a development new in the United States. I understand that the experiments on both types of cable in Detroit, Mich., are only partially completed and I hope we may look forward to further publications containing more complete and comparable data. Meanwhile, I am glad to see that this activity with new cable designs with which I have been connected in Europe since 1927 in the laboratory and since 1932 in practical construction and operation has been vigorously taken up now also in the United States and I have no doubt that this will lead to a final clarification of the most efficient and most economical design for the different practical conditions.

M. HOCHSTADTER (M '30)

(Beverly Hills, Calif.)

A Peace Worth Fighting For

To the Editor:

For several years men prominent in the profession have urged engineers to express their views on social and economic reforms in a more public manner than has been customary. Doctor Wickenden's address, "A Peace Worth Fighting For," published in the March 1942 issue of *Electrical Engineering*, pages 113–19, is an admirable example of such action. He clearly and succinctly sets forth what he believes to be

the philosophy of the war, and the reconstruction in civil life that must inevitably follow. In "Nemesis of American Business" Stuart Chase wrote ". . . the greatest need in all the bewildered world is for philosopher engineers," and that goes today with particular emphasis.

Doctor Wickenden describes some of the factors the treatment of which will condition postwar rehabilitation that will be inevitable. One view that is steadily gaining adherents he states in these words: "It is not too much to say that if civilization is not to pass into a lasting decline we in America shall have to underwrite its rehabilitation." How? He answers thus: ". . . by creating new wealth and a greater national income."

In other words we must lay the foundations for an age of plenty, and in that way achieve economic balance; that is, full production with full employment and ample buying power. In the face of dire economic conditions that seem inevitable after the war under our present capitalistic regimen, that is a large order that only radical measures will satisfy.

When the war is over there will be some seven or eight million men in the armies of Europe (not including Russia) to be demobilized. They must in some way be set to work to live, but wages will be a mere pittance, a bare subsistence. Goods to compete with American products will be marketed at a price much less than it will cost to produce them in the United States. The postwar economic problem is a most serious one. With a national debt perhaps five times that at the close of World War I, the United States Government will be in no position to extend such welfare aid as was done during the depression. The apparent alternative, to maintain production, is to reduce costs by slashing wages and profits; this, however, will invite unprecedented labor troubles that will only make the situation worse. Such a situation is a legitimate outcome of our capitalistic economy, likewise labor racketeering. But it is not inevitable if capital and labor will abandon certain iniquitous practices, and accept co-operative reorganization and rehabilitation. This is what Doctor Wickenden stressed. Economists and other far sighted men have for some time felt that such a change must come, and now we are face to face with a "must" of portentous proportions.

The type of capitalism developed in the United States during the last 60 years made the best showing of which it is capable in the 1920's, and in 1929 showed a national income of nearly $82,000,000,000. In that same year accumulated profits were $12,000,000,000 in excess of what was needed to maintain our domestic economy, and in addition there was social and economic waste amounting to about $60,000,000,000, by reason of practices incidental to our modern brand of capitalism. These two items represent in large part what was potential buying power on the basis of the business transacted. On the basis of possible economic reorganization there should have been realized out of the two items enough to have made the national income of 1929 the equivalent of $120,000,000,000.

Had 1920 economy in the United States been reorganized thus and the sums saved been applied to the low wage scale, there might have been a minimum industrial wage of $2,000. Such a reorganization now would cut production costs sufficiently to avoid serious postwar unemployment. With its economy thus rationalized, with really free initiative and free competition established, the United States would be in line to achieve economic balance and the four freedoms.

WALTER STUART KELLY (A '04)

(Consulting engineer, Brookline, Mass.)

Transmission-Line Equations

To the Editor:

The equations for the performance of uniform transmission lines are:

$$\mathbf{E}_S = \mathbf{E}_R\mathbf{A} + \mathbf{I}_R\mathbf{B} \qquad (1)^*$$

$$\mathbf{I}_S = \mathbf{I}_R\mathbf{A} + \mathbf{E}_R\mathbf{C} \qquad (2)$$

$$\mathbf{E}_R = \mathbf{E}_S\mathbf{A} - \mathbf{I}_S\mathbf{B} \qquad (3)$$

$$\mathbf{I}_R = \mathbf{I}_S\mathbf{A} - \mathbf{E}_S\mathbf{C} \qquad (4)$$

When a line is not uniform, equations (2) and (3) above become

$$\mathbf{I}_S = \mathbf{I}_R\mathbf{D} + \mathbf{E}_R\mathbf{C} \qquad (5)$$

$$\mathbf{E}_R = \mathbf{E}_S\mathbf{D} - \mathbf{I}_S\mathbf{B} \qquad (6)$$

This letter concerns the conventions involving the use of the A and D constants and the difficulties which arise when power flow is reversed. The D constant was first presented as far as the writer has been able to ascertain by R. D. Evans and H. K. Sels in their paper on "Power Limitations of Transmission Systems," AIEE *Transactions*, volume 43, 1924, pages 26–38. In that paper attention was called to the fact that if two or more nonuniform circuits were combined to obtain over-all constants, the values of A and D constants would be interchanged if the nonuniform circuits were combined in the reverse direction. However, the B and C constants would be unchanged. In this respect, the expressions, uniform and nonuniform, are loose but have come to have accepted usage. It would be more accurate to say that the line is or is not identical when viewed from opposite ends. Although the A, B, C, and D constants are functions only of the physical construction of the circuit and the frequency, the nomenclature of equations (1), (4), (5), and (6) implies that the A and D constants are functions of power flow and a recent reference book, "Electrical Transmission and Distribution Reference Book," published by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., on the subject goes so far as to define the A constant as the open circuit voltage ratio and the D constant as the short-circuit current ratio. No mention is made in the reference book of the fact that the values of the A and D constants interchange if the sending and receiving ends of the line are interchanged. According to this system, the equivalent impedance (used in impedance relay work) is always expressed as B/D with D having two values depending upon which end of the line is short circuited. For his own convenience, the writer keeps the values straight by setting up an equivalent π circuit as shown in Figure 1.

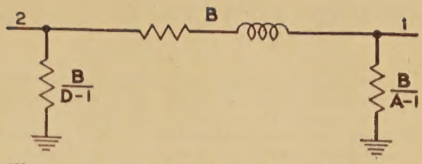


Figure 1. Equivalent Pi circuit, in terms of general circuit constants

When the line is short-circuited at 1, the equivalent impedance is the parallel of B and $B/(D-1)$ which is B/D. Likewise when the line is short-circuited at 2, the equivalent impedance is B/A. This scheme, however, is inconsistent with the nomenclature of equations (1), (4), (5), and (6), and the writer hopes that this letter will start a discussion which will provide consistent expressions for the equivalent impedances and at the same time devise designations for or use of the A and D constants which will tie them into the fixed line characteristics and not into the direction of power flow. Perhaps the committee on power transmission and distribution can be persuaded to consider the case. One possible scheme would be to fix arbitrarily the order of calculating the constants according to the Evans and Sels tables and then to designate E_s as E_2 and E_r as E_1 in those tables.

The basic equations (1), (4), (5), and (6), then should be revised, and using power flows as shown by the arrows below, would be:

$2 \longrightarrow 1$

$$\mathbf{E}_2 = \mathbf{E}_1\mathbf{A} + \mathbf{I}_1\mathbf{B} \qquad (7)$$

$$\mathbf{I}_2 = \mathbf{I}_1\mathbf{D} + \mathbf{E}_1\mathbf{C} \qquad (8)$$

$$\mathbf{E}_1 = \mathbf{E}_2\mathbf{D} - \mathbf{I}_2\mathbf{B} \qquad (9)$$

$$\mathbf{I}_1 = \mathbf{I}_2\mathbf{A} - \mathbf{E}_2\mathbf{C} \qquad (10)$$

$2 \longleftarrow 1$

$$\mathbf{E}_2 = \mathbf{E}_1\mathbf{A} - \mathbf{I}_1\mathbf{B} \qquad (11)$$

$$\mathbf{I}_2 = \mathbf{I}_1\mathbf{D} - \mathbf{E}_1\mathbf{C} \qquad (12)$$

$$\mathbf{E}_1 = \mathbf{E}_2\mathbf{D} + \mathbf{I}_2\mathbf{B} \qquad (13)$$

$$\mathbf{I}_1 = \mathbf{I}_2\mathbf{A} + \mathbf{E}_2\mathbf{C} \qquad (14)$$

It will be seen that when set up in this manner, the only difference between equations (7) through (10) with respect to equations (11) through (14) in order, is in the signs of the last terms. This suggests a possible combination of these equations as follows:

$2 \; \boxed{DCBA} \; 1$

$$\mathbf{E}_2 = \mathbf{E}_1\mathbf{A} \pm \mathbf{I}_1\mathbf{B} \qquad (15)^{**}$$

$$\mathbf{I}_2 = \mathbf{I}_1\mathbf{D} \pm \mathbf{E}_1\mathbf{C} \qquad (16)$$

$$\mathbf{E}_1 = \mathbf{E}_2\mathbf{D} \mp \mathbf{I}_2\mathbf{B} \qquad (17)$$

$$\mathbf{I}_1 = \mathbf{I}_2\mathbf{A} \mp \mathbf{E}_2\mathbf{C} \qquad (18)$$

V. J. CISSNA (M'30)

(Power engineering and construction department, Tennessee Valley Authority, Chattanooga)

* Boldface letters represent vector quantities and move as shown.

***Note:* Signs ± or ∓ change with direction of power flow. When flow is from 2 to 1 the top signs are used. When flow is from 1 to 2, the bottom signs are used.

NEW BOOKS • • •

The following new books are among those recently received from the publishers. Books designated ESL are available at the Engineering Societies Library; these and thousands of other technical books may be borrowed from the library by mail by AIEE members. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books. All inquiries relating to the purchase of any book reviewed in these columns should be addressed to the publisher of the book in question.

Table of Sine and Cosine Integrals from 10 to 100. Prepared by the Federal Works Agency, Work Projects Administration for the City of New York, N. Y., conducted under the sponsorship of and for sale by the National Bureau of Standards, Washington, D. C., 1942. 185 pages, charts, etc., 11 by 8 inches, cloth, $2. (ESL).

This volume supplements the two previous volumes of sine, cosine, and exponential integrals by providing sine and cosine intergrals, calculated to ten decimal places, for the range of x between 10 and 100, at intervals of 0.01. These integrals are encountered in many branches of physics and electrical engineering, and the volume is expected to meet the needs of workers in these fields.

Mathematics of Modern Engineering, Volume 2 (Mathematical Engineering). By E. G. Keller. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1942. 309 pages, illustrations, etc., $9^1/_2$ by 6 inches, cloth, $4. (ESL).

The three-volume work of which this is the second volume aims to present those aspects of mathematics which the experience of a large manufacturing organization, in dealing with mechanical and electrical investigations, has found to be of most value to engineers. This volume contains an explanation and elaboration of the fundamental method of mathematical engineering which includes the reduction of physical phenomena to a mathematical system and the solution of that system.

Electric Power Stations, volume 2. By T. H. Carr. D. Van Nostrand Company, New York, 1941. 440 pages, illustrations, etc., 9 by $5^1/_2$ inches, cloth, $9. (ESL).

The aim of this two-volume English book is to provide an account of the general principles that govern the design, construction, and operation of electric power stations, which will assist the designer to choose, from the plant available, that which best fulfills the conditions to be met, and to arrange it in the most economical way. The present volume deals with the electrical equipment, station organization, and costs.

Electrical Transmission and Distribution Reference Book. By central-station engineers of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., 1942. 570 pages, illustrations, etc., 12 by $8^1/_2$ inches, cloth, $5. (ESL).

This book brings together, in convenient form for reference, a large amount of practical, up-to-date information on the design and operation of transmission and distribution systems. Each chapter is by a specialist in the subject, and nearly all chapters have bibliographies. Appendixes contain tabulated statistical data on transmission lines, power systems, and transformer circuits.

Elementary Structural Analysis and Design, Steel, Timber, and Reinforced Concrete. By L. E. Grinter. Macmillan Company, New York, 1942. 383 pages, illustrations, etc., $9^1/_2$ by 6 inches, cloth, $3.75. (ESL).

Intended for students of architecture and mechanical and electrical engineering and others interested in buildings and miscellaneous structures, except bridges. Although the greatest emphasis is placed on steel structures, considerable attention is given to reinforced concrete, and timber is treated adequately. Special chapters on timber-roof trusses and on column footings are included.

Marine Diesel Handbook. By L. R. Ford. Diesel Publications, New York, 1942. 896 pages, illustrations, etc., 9 by 6 inches, fabrikoid, $7; in foreign countries, $8. (ESL).

The machinery of a modern motorship is described and explained in this handbook designed for those in charge of operation and maintenance. The principles of the Diesel engine, the types in use and their construction are explained. Chapters deal with fuel, propulsion methods, Diesel-electric drives, supercharging, propellers, speed regulation, suppression of vibration and noise, electricity on the motorship, and accessory equipment.

Mathematics Dictionary. Compiled and edited by G. James and R. C. James. The Digest Press, Van Nuys, Calif., 1942. 259 pages, diagrams, etc., $9^1/_2$ by 6 inches, cloth, $3. (ESL).

This dictionary is based upon modern textbooks, and aims to give the meaning of the basic mathematical words and phrases, and to cover exhaustively all terms from arithmetic through calculus, including the technical terms commonly used in the application of these subjects. Many illustrative examples and figures are included, and an appendix provides a number of useful mathematical tables.

Postwar Planning in the United States. By George B. Galloway. The Twentieth Century Fund, New York, 1942. 169 pages, paper, 60 cents.

A report of the activities of more than 100 governmental and private agencies and commercial firms throughout the country engaged in postwar planning research. The summary catalogues the leading agencies, lists and classifies the projects each has under way, and includes a bibliography of current books, pamphlets, and articles on the subject.

Condition Percent Tables for Depreciation of Unit and Group Properties (Bulletin 156). By Robley Winfrey. Iowa State College, Ames, Iowa, 1942. 177 pages, tables, paper, $3. (ESL).

Tables are assembled for the determination of annual depreciation and accrued depreciation of physical properties on the basis of age and probable life of the property units, accompanied by an explanation of their use and a description in graph and final equation form of the 18-type frequency curves.

Modern Electroplating. Electrochemical Society, New York, N. Y., 1942. 399 pages, illustrations, etc., $9^1/_2$ by 6 inches, cloth, $5.50 (ESL).

Aims to provide a comprehensive survey of modern practice, prepared by various experts and provided with copious references to the literature. The opening paper describes general principles and methods. Succeeding material deals with the various metals.

PAMPHLETS • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

How Factory Accidents Happen, Descriptions of Certain Industrial Accidents, Notified to His Majesty's Inspectors of Factories. Ministers of Labor and National Service, Great Britain, November 1941. Diagrams $9^1/_2$ by 6 inches, 33 pages, paper (obtainable from British Library of Information, New York, N. Y., 15 cents).

Aircraft Engine Trouble Shooting Chart. By Andrew Wallace. The Norman W. Henley Publishing Company, New York, N. Y., 1942. 22 by 32 inches, 75 cents.

Enclosed Switch Standards. National Electrical Manufacturers' Association, New York, N. Y., 1942. 19 pages, paper, 60 cents.

Power Switchgear Assemblies Standards. National Electrical Manufacturers' Association, New York, N. Y., 1942. 65 pages, paper, $3.25.

Transformer Standards. National Electrical Manufacturers' Association, New York, N. Y., 1942. 67 pages, paper, $3.

Post-War Planning. National Resources Planning Board, Washington, D. C., 1942. 32 pages, paper, 5 cents.